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ERRATA.

Page 446, line 19 from bottom, for *Centronotus gunellus* read *Centronotus gunnellus.*

474, line 12 from bottom, for *Pompilus nesophila* read *Pompilus nesophilus.*

503, line 9 from bottom, for *Chiton* (*Ischnochiton*) *carribæorum* read *Chiton* (*Ischnochiton*) *caribbæorum.*

555, line 7 from top, for *A. jaspicea* read *A. jaspidea.*

THE JOURNAL

OF

THE LINNEAN SOCIETY.

Descriptions of a new Genus and of some new Species of *Galerucinæ*, also Diagnostic Notes on some of the older described Species of *Aulacophora*. By JOSEPH S. BALY, F.L.S.

[Read 6th May, 1886.]

MANY of the insects characterized in the following paper were collected in the Eastern Archipelago by Mr. A. R. Wallace. Types of all the species mentioned are contained in my collection.

Genus AULACOPHORA.

Many of the species of this genus, more especially those described by the older authors, are in a state of great confusion, arising to some extent from the great similarity in general appearance and coloration of many of them; but principally from the brief descriptions given by the various authors and from the total absence of any reference to structural characters.

In the present paper I have attempted to work out some of these species, pointing out the structural characters by which they may be separated. I have retained, in most cases, the old names, although I cannot be sure in every instance that the species to which they are assigned were those from which the descriptions were originally drawn.

I have not attempted to work out the whole genus, many species sufficiently characterized by their respective describers, as well as others which, from want of sufficient material, I have not had the opportunity of studying, having been omitted.

The Synoptical Table given below will, I trust, be of use to the future student of the genus.

Table of Species.

MALES.

I. Antennæ filiform.
A. Elytra transversely depressed or excavated below the basilar space.
A. Apical segment of abdomen trilobate, the middle lobe oblong or oblong-quadrate, its surface deeply concave or sulcate longitudinally.
a. Antennæ (the base sometimes excepted) black or fuscous.
a^1. Elytra entirely black.
b^1. Breast black, the abdomen fulvous or flavous .... 1. **nigripennis.**
b^2. Breast and abdomen rufo-fulvous .... 2. **melanopus.**
a^2. Elytra black, with flavous bands or markings.
c^1. Pygidium fulvous.................................. 3. **albofasciata.**
c^2. Pygidium black .... 4. **pygidialis.**
b. Antennæ fulvous or flavous, rarely stained towards the apex with fuscous, basal joints sometimes fuscous or black.
d^1. Elytra entirely black.
e^1. Body broadly ovate.............................. 5. **melanoptera.**
e^2. Body oblong-ovate .... 6. **atripennis.**
d^2. Elytra black, the extreme basal margin rufous. 7. **lata.**
d^3. Elytra black, their apices to a greater or less extent rufous...................................... 8. **rosea.**
d^4. Elytra black, with flavous markings .... 9. **instabilis.**
B. Apical segment of abdomen trilobate, middle lobe quadrate or subquadrate, its disk plane or only slightly concave.
a. Thorax rufous or flavous.
f^1. Elytra entirely black .... 10. **Boisduvali.**
f^2. Elytra black with flavous markings.
g^1. Body not exceeding 4 lines in length ...... 11. **propinqua.**
g^2. Body 5 lines or more in length .... 12. **rubrozonata.**
f^3. Elytra flavous, with black patches or markings. 13. **approximata.**
f^4. Elytra flavous, the posterior half black ...... 14. **postica.**
f^5. Elytra entirely flavous .... 15. **testacea.**
b. Thorax black.. 16. **flaviventris.**
B. Elytra not transversely depressed or excavated below the basilar space.
A. Trilobate apex of abdomen with its middle lobe deeply concave or longitudinally sulcate.
h^1. Elytra flavous, unicolorous.
i^1. Antennæ, at the base excepted, nigro-fuscous.
j^1. Legs entirely flavous .... 17. **abdominalis.**
j^2. Four hind legs black .... 18. **Fabricii.**
i^2. Antennæ flavous or fulvous.
k^1. Scutellum black or nigro-fuscous.
l^1. Thoracic sulcation deeply excavated on the middle disk, obsolete or interrupted towards the lateral margin. 19. **nigroscutata.**

l^2. Thoracic sulcation entire, more deeply impressed on the middle disk .... 20. **Wallacii.**

k^2. Scutellum flavous or fulvous.

m^1. Face armed on either side below the antennæ with a compressed tubercle. 21. **cornuta.**

m^2. Face unarmed.

n^1. Thoracic groove deeply excavated and abruptly sinuate on the middle disk, the hinder margin of the groove bitorulose .... 22. **foveicollis.**

n^2. Thoracic groove straight or only moderately sinuate on the middle disk, its hinder margin not torulose.

o^1. Legs entirely flavous .... 23. **similis,** var.

o^2. Anterior pair of legs fulvous, the two hinder pairs black or nigro-piceous ... 23. **similis.**

^{2}. Elytra flavous, with black markings.

p^1. Each elytron with two black spots .... 24. **tetraspilota.**

p^2. Each elytron with four black spots .... 25. **octomaculata.**

k^3. Elytra nigro-cæruleous, thoracic groove deeply excavated on the middle disk .... 26. **excavata.**

k^4. Elytra nigro-piceous, narrowly edged with flavous; face with two compressed tubercles. 21. **cornuta,** var.

B. Intermediate lobe of apical segment of abdomen quadrate or subquadrate, plane or slightly concave.

q^1. Elytra flavous.

u^1. Legs black or nigro-piceous; the labrum and the lower portion of the clypeus black. 27. **coffeæ.**

u^2. Legs, labrum, and lower surface of clypeus flavous... 28. **bicolor,** var. F & G.

q^2. Elytra flavous, with black markings!........... 28. **bicolor,** var. D & E.

q^3. Elytra black, the apex rufo-fulvous .... 28. **bicolor,** type.

q^4. Elytra entirely black .... 29. **nigrivestis.**

q^5. Elytra black, fulvous at the base .... 30. **Downesi.**

II. Antennæ with the apical joint alone incrassate.

v^1. Elytra transversely depressed below the basilar space .... 31. **antennata.**

v^2. Elytra not depressed below the basilar space. 32. **luteicornis.**

III. Antennæ with three or four intermediate joints dilated.

w^1. Elytra flavous, with a submarginal black line. 33. **Stevensi.**

w^2. Elytra viridi-æneous .... 34. **Duboulayi.**

FEMALES.

I. Surface of elytra plane or obsoletely sulcate.

A. Elytra transversely depressed or excavated below the basilar space.

A. Thorax nigro-fulvous or flavous.

a. Apex of last abdominal segment entire.

a^1. Body entirely flavous .... 35. **unicolor.**

a^2. Breast and abdomen black; legs and antennæ flavous *.

b^1. Body above flavous .... 15. **testacea.**

---

* *A. palustris*, Perroud, belongs to this section, but differs from *A. testacea* in having the legs and antennæ black.

b^2. Posterior half of elytra black............... 14. **postica.**
a^3. Breast, legs, and antennæ black; elytra black with yellowish markings .... 11. **propinqua**, var.
a^4. Breast and abdomen (the apical segment sometimes excepted) rufo-fulvous or fulvous; elytra more or less black.
  c^1. Elytra entirely black.
    d^1. Antennæ black.............................. 2. **melanopus.**
    d^2. Antennæ flavous or fulvous, the basal joint sometimes piceous or black.
      e^1. Labrum black .... 10. **Boisduvali.**
      e^2. Labrum rufo-fulvous .... 31. **antennata.**
  c^2. Elytra black, the basal margin more or less distinctly edged with rufous .... 7. **lata.**
  c^3. Elytra black, their apices to a greater or less extent rufous .... 8. **rosea.**
  c^4. Elytra black, with flavous bands or markings.
    f^1. Legs entirely black.
      g^1. Body not exceeding 4 lines in length .... 11. **propinqua.**
      g^2. Body upwards of 4 lines in length . 12. **rubrozonata.**
    f^2. Legs with the thighs and the basal portion of the tibiæ rufo-fulvous or flavous, the rest black.
      h^1. Pygidium black .... 4. **pygidialis.**
      h^2. Pygidium rufo-flavous .... 3. **albofasciata.**
    f^3. Legs entirely flavous .... 9. **instabilis.**
  c^5. Elytra nigro-piceous, the lateral margin and the suture from below the base to the apex fulvous .... 38. **semilimbata.**
  c^6. Elytra flavous, with black markings.
    i^1. Surface of elytra obsoletely sulcate...... 36. **nigrosignata.**
    i^2. Surface of elytra plane .... 13. **approximata.**
b. Apex of anal segment of abdomen emarginate.
    k^1. Antennæ black.............................. 1. **nigripennis.**
    k^2. Antennæ and legs flavous.
      l^1. Body broadly ovate .... 5. **melanoptera.**
      l^2. Body oblong-ovate .... 6. **atripennis.**
B. Thorax entirely black .... 16. **flaviventris.**

B. Elytra not transversely depressed or excavated below the basilar space.
  a. Apex of anal segment of abdomen entire.
    m^1. Body not exceeding 3 lines in length.
      n^1. Elytra nigro-piceous, the base flavous ... 30. **Downesi.**
      n^2. Elytra flavous, with black markings.
        o^1. Elytra each with four black spots...... 25. **octomaculata.**
        o^2. Elytra each with two black spots ...... 24. **tetraspilota.**
    m^2. Body 3 lines in length or upwards.
      p^1. Body subelongate or oblong, slightly dilated posteriorly.
        q^1. Elytra flavous.
          u^1. Lower portion of clypeus and the labrum black .. .. 27. **coffeæ.**
          u^2. Lower portion of clypeus and the labrum flavous .... 28. **bicolor**, var.
        q^2. Elytra variable in tint and markings, not metallic .... 28. **bicolor.**
        q^3. Elytra metallic green .... 34. **Duboulayi.**

- p^2. Body ovate or oblong-ovate, dilated posteriorly.
    - v^1. Elytra flavous, the suture and a submarginal vitta black .... 33. **Stevensi.**
    - v^2. Elytra and abdomen black............... 37. **Lewisii.**
- *b.* Apex of anal segment of abdomen rounded, its middle portion produced into an oblong process .... 19. **nigroscutata.**
- *c.* Apex of anal segment of abdomen slightly sinuate, its surface deeply concave on either side .... 22. **foveicollis.**
- *d.* Apex of anal segment of abdomen broadly subangulate-emarginate .... 18. **Fabricii.**
- *e.* Apex of anal segment of abdomen abruptly concave-emarginate .... 20. **Wallacii.**
- *f.* Apex of anal segment of abdomen broadly concave-emarginate .... 21. **cornuta.**
- *g.* Apex of anal segment of abdomen bilobate.
    - w^1. Lobes concave .... 23. **similis.**
    - w^2. Lobes plane.
        - x^1. Elytra flavous .... 40. **excisa.**
        - x^2. Elytra nigro-cæruleous .... 26. **excavata.**
- *h.* Apex of anal segment of abdomen bisinuate ... 39. **Duvivieri.**
- *i.* Apex of anal segment of abdomen trilobate.
    - y^1. Lobes nearly equal in length .... 41. **Mouhoti.**
    - y^2. Lobes with the intermediate much shorter than the lateral ones .... 32. **luteicornis.**

II. Elytra strongly costate .... 42. **costatipennis.**

1. AULACOPHORA NIGRIPENNIS, *Motsch. Etud. Entom.* 1857, p. 38.

A. atripennis, *Hope, Proc. Ent. Soc.* 1841, p. 64.

Anguste ovata, postice ampliata, convexa, fulva aut flava, antennis, pedibus, pectore elytrisque nigris, his infra basin transversim depressis, distincte punctatis; thorace vix pone medium sat profunde transversim sulcato, sulco fere recto. Long. 3–3½ lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio oblongo, longitudinaliter concavo.

Fœm. Abdominis segmento anali apice concavo-emarginato.

Hab. Mantchuria; Japan (*Lewis*); China (*Bowring*).

Labrum and antennæ black, the latter with the basal joints, and sometimes with the four or five outer ones, nigro-piceous. Thorax nearly twice as broad as long; sides sinuate and slightly diverging from the base to beyond the middle, thence obliquely converging towards the apex; disk rather strongly sulcate just behind the middle. Elytra distinctly punctured.

2. AULACOPHORA MELANOPUS, *Blanch. Voy. au Pôle Sud*, p. 316, pl. 19. fig. 20.

Anguste oblongo-ovata, postice ampliata, convexa, rufo-fulva, nitida,

antennis, pedibus totis, pygidio elytrisque nigris; thorace lævi, sat profunde transversim sulcato; elytris infra basin transversim depressis, tenuissime punctatis. Long. 3½–5 lin.

Var. A. Femoribus pygidioque rufo-fulvis.

***Mas.* Abdominis segmento anali trilobato, lobo intermedio transverso-quadrato, angulis anticis rectangulis, apice truncato, disco longitudinaliter sulcato.**

***Fœm.* Abdominis segmento anali late sed leviter angulato-emarginato.**

Hab. New Guinea, Dorey; Amboina (*Wallace*).

Antennæ slender, filiform, nearly equal to the body in length in either sex, black, the two to four lower joints usually rufo-piceous; labrum and mouth nigro-piceous. Thorax transverse; sides nearly straight and parallel from the base to beyond the middle, thence rounded and converging towards the apex, anterior angle obtuse; disk smooth, impunctate, discoidal groove nearly straight, more deeply impressed on either side the median line. Elytra dilated posteriorly, convex, transversely excavated below the basilar space, very minutely punctured.

The dark antennæ, equally long in both sexes, will separate this species from others with similarly coloured elytra. It is with some doubt that I have placed var. A under the same specific head; it agrees, however, entirely in structural characters.

3. AULACOPHORA ALBOFASCIATA. Anguste ovata, postice paullo ampliata, convexa, fulvo-nitida, antennis, ore, tibiis tarsisque nigro-piceis aut fuscis; thorace transverso, disco transversim sulcato; elytris convexis, infra basin prope suturam leviter transversim excavatis, nigris, utrisque fascia obliqua prope medium communi, ad marginem abbreviata, albida. Long. 4–5 lin.

Var. A, ♂. Elytrorum fascia albida fere obsoleta.

***Mas.* Abdominis segmenti analis lobo intermedio oblongo, profunde concavo.**

***Fœm.* Abdominis segmento ultimo late obtuso.**

Hab. New Guinea, Dorey (*Wallace*).

Head scarcely longer than broad, trigonate. Antennæ slender, equal to the body in length in both sexes; the four or five lower joints sometimes obscure fulvous; eyes in the male large, prominent. Thorax nearly twice as broad as long; sides slightly diverging or nearly parallel from the base to beyond the middle, thence obliquely converging to the anterior angle; disk transversely sulcate, the sulcation rather more deeply impressed on either side. Elytra broader than the thorax, rather broadly dilated behind the middle, convex, rather strongly excavated below the basilar space, minutely punctured, the puncturing on the hinder disk nearly obsolete.

4. AULACOPHORA PYGIDIALIS. **Oblongo-ovata, postice ampliata, convexa, flava, nitida; abdominis segmento ultimo plus minusve, pygidio, pedibus posticis fere totis, tarsis anticis quatuor, tibiis intermediis (basi exceptis), labro, antennis (basi exceptis) elytrisque nigris; his infra basin transversim excavatis, minute punctatis, fascia lata prope medium, interdum interrupta aut abbreviata, flavo-fulva; thorace vix pone medium transversim sulcato. Long. 3–3½ lin.**

Var. A. Abdominis disco plus minusve nigro-piceo tincto.

***Mas.* Abdominis segmento anali trilobato, lobo intermedio oblongo, profunde concavo.**

***Fœm.* Abdominis segmento anali apice obtuso, integro.**

Hab. Aru Islands; New Guinea, Dorey; Ceram; Ké Islands (*Wallace*).

Antennæ slender, filiform, black, more or less piceo-fulvous at the base. Thorax more than half as broad again as long; sides obliquely diverging from the base to beyond the middle, subangulate anteriorly; disk transversely sulcate just behind the middle. Elytra very finely punctured.

Closely allied to *A. albofasciata*, smaller and the male broader than that species, its eyes less prominent; the coloration of the legs varies greatly in degree.

5. AULACOPHORA MELANOPTERA, *Boisduval, Voy. de l'Astrol.* p. 549.

Late ovata, postice ampliata, convexa, flavo-rufa, nitida; elytris nigris, labro piceo; thorace lateribus fere parallelis, obtusis, ad apicem convergentibus, disco minute punctato, transversim sulcato; elytris convexis, infra basin prope suturam transversim excavatis, minute punctatis. Long. 4 lin.

***Mas.* Abdominis segmento anali trilobato, lobo intermedio oblongo, profunde concavo.**

***Fœm.* Abdominis segmento anali apice subangulato-emarginato.**

Var. A, ♂. Tarsis piceis.

Galeruca melanoptera, *Boisduval, Voy. de l'Astrol.* p. 549, t. 8. fig. 11.

Hab. Celebes (*Wallace*).

Antennæ slender, filiform, nearly three fourths the length of the body; labrum piceous. Thorax nearly twice as broad as long; sides nearly parallel, obliquely converging towards the apex; disk smooth, minutely punctured, transverse groove rather more deeply impressed on either side. Elytra broadly dilated posteriorly, convex, transversely excavated below the basilar space; minutely punctured, lateral limb reflexed, more strongly punctured than the disk.

Broader in both sexes than *A. atripennis*, Fabr., the lateral margin of the elytra broader and more strongly punctured.

6. AULACOPHORA ATRIPENNIS, *Fabr. Syst. El.* i. p. 482.

Oblongo-ovata, postice ampliata, convexa, rufo-fulva aut rufa, nitida, antennis flavis, articulo basali interdum rufo-piceo tincto; thorace transversim sulcato; elytris nigris, tenuissime punctatis, labro (*in mare*) nigro-piceo. Long. 3–4 lin.

Var. A. Pedibus rufo-piceis.

***Mas.* Abdominis segmento anali trilobato, lobo intermedio oblongo, profunde concavo-excavato.**

***Fœm.* Abdominis segmento anali apice leviter angulato-emarginato.**

Hab. Sumatra; Amboina; Gilolo; Tondano; Ké Islands (*Wallace*).

Antennæ slender, filiform. Thorax transverse; sides obliquely diverging from the base to beyond the middle, thence converging towards the apex; disk smooth, impressed on either side with a few minute punctures; discoidal sulcation nearly straight. Elytra dilated posteriorly, convex, transversely excavated below the basilar space, very finely punctured.

This species is smaller in size than either of the following two; the deeply concave intermediate lobe of the anal segment of the abdomen in the male, together with the obtusely emarginate apex of the same segment in the female, will separate it from either. Many of the specimens that I have seen differ from the diagnosis given by Fabricius in not having the basal joint of the antennæ darker than the following ones; in other respects they agree with the description given. I possess three specimens of the male; in this sex the labrum is piceous, in the other one it is concolorous with the upper face; in some individuals the legs are stained with piceous.

7. AULACOPHORA LATA. **Late ovata, postice ampliata, convexa, rufo-fulva, nitida, tarsis, tibiis plus minusve elytrisque nigris, his basi extrema plus minusve rufo-marginatis; antennis pallide flavis; thorace transverso, lateribus obtuse rotundatis, reflexis; disco trans-**

versim sulcato, lævi, ad latera minute punctato; elytris late oblongo-ovatis, postice ampliatis, convexis, infra basin transversim excavatis, minute punctatis, limbo externo reflexo. Long. 4–5½ lin.

Mas. **Abdominis segmento anali trilobato, lobo intermedio quadrato, longitudinaliter sulcato.**

Fœm. **Abdominis segmento anali apice obtuso; pygidii apice leviter emarginato.**

Hab. Ceram; Macassar; Celebes; Gilolo; Batchian (*Wallace*).

Antennæ filiform, nearly equal to the body in length in both sexes; labrum concolorous with the upper face. Thorax nearly twice as broad as long; sides obtusely rounded, the hinder angle obsolete, the anterior one very minute; lateral margin more broadly reflexed than in most species of the genus; disk smooth, very minutely punctured on the sides, transverse sulcation nearly straight. Elytra broadly oblong-ovate, dilated posteriorly, convex, transversely excavated below the basilar space, minutely punctured; outer limb rather broadly dilated and reflexed for nearly its whole extent.

This species is closely allied to *A. rosea*, Fabr.: both insects closely agree in the form of the thorax and in all other structural characters; but the present one is distinctly broader in form and its elytra are (the extreme basal margin excepted) unicolorous.

8. AULACOPHORA ROSEA, *Fabr. Syst. El.* i. p. 479.

Ovata, postice ampliata, convexa, rufo-fulva aut rufa, nitida, tibiis tarsisque nigris, antennis flavis, articulo primo sæpe rufo; thorace sat profunde transversim sulcato; lateribus obtuse rotundatis, reflexis; elytris infra basin transversim depressis, nigris, apice plus minusve rufis. Long. 3½–6 lin.

Mas. **Abdominis segmenti analis lobo intermedio late oblongo, longitudinaliter sulcato.**

Fœm. **Abdominis segmento anali integro.**

Hab. Sumatra; Java; Philippine Islands; Malacca.

This species so closely resembles *A. lata* in the form of its thorax and in other structural characters, that I do not give a detailed description; it is separated by its less broadly ovate form and by the rufous apex of its elytra. The rufous coloration of the apex of the elytra extends upwards to a greater or smaller extent over the disk. *A. albicornis*, Chapuis, is apparently identical with the present insect; at any rate, I cannot separate it on the slight diagnosis given by the author.

9. **AULACOPHORA INSTABILIS.** Oblongo-ovata, postice ampliata, flava, nitida, antennis extrorsum fuscis; thorace transversim sulcato, sulco fere recto; elytris convexis, infra basin leviter transversim depressis, nigris, fascia interrupta lata prope medium, interdum interrupta aut extrorsum abbreviata, flava. Long. 4 lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio oblongo, concavo, longitudinaliter sulcato.

Fœm. Abdominis segmento anali apice obtuso.

Hab. Batchian; Mysol (*Wallace*).

Antennæ slender, filiform, entirely, or with the apices of the six or seven outer joints alone, fuscous. Thorax about one half broader than long; sides parallel and slightly sinuate from the base to beyond the middle, thence slightly converging towards the apex; disk deeply impressed with a transverse sulcation. Elytra dilated posteriorly, convex, slightly flattened along the suture, and faintly excavated behind the basilar space; nitidous, very minutely punctured.

10. **AULACOPHORA BOISDUVALI.** Ovata, postice ampliata, convexa, rufo-fulva aut fulva, labro nigro-piceo, nitido, antennis flavis; tibiis plus minusve tarsisque piceis, elytris nigris; thorace profunde transversim sulcato. Long. 4–5 lin.

Var. A. Labro rufo-fulvo.

Mas. Abdominis segmento anali trilobato, lobo intermedio transverso-subquadrato, plano.

Fœm. Abdominis segmento anali apice obtuso.

Hab. New Guinea (*Boisduval*); Borneo, Sarawak; Celebes; Bouru (*Wallace*).

Antennæ slender and filiform in either sex; nearly equal to the length of the body in the male, shorter in the other sex; labrum nigro-piceous, rarely concolorous with the upper face. Thorax with its sides sinuate and slightly diverging from the base to beyond the middle, thence obliquely rounded and converging towards the apex; upper surface smooth, finely but not closely punctured; discoidal sulcation nearly straight, deeply impressed, more deeply so on the sides. Elytra much broader than the thorax, their sides nearly parallel anteriorly, abruptly dilated posteriorly, convex, slightly excavated transversely below the basilar space, minutely punctured.

Nearly allied in coloration to *A. lata*, differing in the form of the thorax, the sides of which in the present species are obtusely angulate and not rounded as in the before-named insect; there is also a distinct difference, both in the anal segment of the abdomen in the male and in the male genital organ.

11. **Aulacophora propinqua.** Anguste oblongo-ovata, postice ampliata, convexa, flavo-fulva, nitida, labro, antennis (his basi interdum exceptis), pedibus elytrisque nigris; his infra basin transversim excavatis, tenuissime punctatis, utrisque fascia lata prope medium, plerumque ad marginem abbreviata, flavo-fulva. Long. 3½–4 lin.

Var. A. Pectore nigro, cæteris ut in typo.

Var. B. Pectore, abdomine pygidioque nigris, cæteris ut in typo.

Mas. Abdominis segmento anali trilobato, lobo intermedio flavo, obtuso.

Fœm. Abdominis segmento anali obtuso.

Hab. New Guinea, Dorey; Ké Islands; var. A, Batchian; var. B, Sulu Islands (*Wallace*).

Antennæ slender, filiform. Thorax about one half as broad again as long; sides nearly straight and slightly diverging from the base to beyond the middle; upper surface transversely sulcate behind the middle. Elytra dilated posteriorly, distinctly excavated on the suture below the basilar space, very minutely punctured.

Var. B is at first sight very similar to *A. dorsalis*, Boisduval; but that species is smaller, and its elytra are more strongly punctured and not depressed below the base.

12. **Aulacophora rubrozonata**, *Blanch. Voy. au Pôle Sud*, p. 345, pl. 19. fig. 19.

Ovata, postice ampliata, convexa, rufa aut fulva, nitida, antennis (his basi plerumque exceptis) pedibusque nigris; thorace sat profunde transversim sulcato; elytris infra basin leviter transversim depressis, fere impunctatis, nigris, fascia lata mediali rufa aut fulva. Long. 4–5 lin.

Var. A. Elytrorum margine ápicali rufo aut fulvo, cæteris ut in typo.

Var. B. Elytris fulvis, utrisque basi lata, maculaque subapicali, nigra.

Var. C. Elytris macula subapicali nigra obsoleta.

Mas. Abdominis segmento anali trilobato, lobo intermedio quam lateralia paullo longiore, plano, apice obtuse rotundato.

Fœm. Abdominis segmento anali apice obtuso.

Hab. New Guinea, Dorey; Celebes (*Wallace*).

Head longer than broad, trigonate; mouth nigro-piceous or piceous. Antennæ slender, rather shorter than the body. Thorax nearly twice as broad as long; sides slightly sinuate and very slightly diverging from the base to beyond the middle; disk deeply impressed with a transverse sulcation. Elytra nitidous, nearly impunctate.

13. **Aulacophora approximata.** Anguste oblongo-ovata, postice ampliata, convexa, fulvo-flava, nitida, tibiis (basi exceptis) tarsisque nigro-fuscis; thorace transversim sulcato, sulci medio leviter sinuato; elytris obsolete sulcatis, lævibus, minute punctatis, utrisque fascia basali plagaque pone medium, nigris. Long. 3½–5 lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio quadrato, leviter concavo.

Fœm. Abdominis segmento anali apice obtuso.

Hab. Celebes (*Wallace*).

Antennæ slender, filiform, nearly equal to the body in length, their outer joints more or less stained with fuscous. Thorax rather more than one half broader than long; sides nearly straight and parallel from the base to beyond the middle; disk smooth, deeply impressed transversely, the sulcation faintly sinuate in the median line. Elytra oblong-ovate, dilated posteriorly, very finely punctured; a common transverse band at the base, and a subrotundate patch halfway between the middle and apex of each elytron, black.

The pale underside, together with the absence of any longitudinal sulcations on the elytra, will separate the female of this species from that of *A. nigrosignata* (sp. 36); the male of the latter insect is unknown to me.

14. **Aulacophora postica**, *Chapuis, Ann. Soc. Ent. Belg.* xix. 1876, p. xcix.

Elongato-ovata, postice ampliata, sordide fulva, nitida, pedibus posterioribus quatuor, pectore, abdomine elytrorumque dimidio postico nigris; thorace sat profunde transversim sulcato; elytris infra basin leviter transversim depressis, distincte punctatis. Long. 4½–5 lin.

Mas. Abdominis segmenti analis lobo intermedio oblongo, profunde longitudinaliter sulcato.

Fœm. Abdominis segmento anali apice leviter sinuato.

Hab. Philippine Islands; Java; Malacca.

Thorax nearly twice as broad as long; sides nearly straight and slightly diverging from the base to beyond the middle; disk transversely sulcate, the sulcation nearly straight. Elytra obsoletely depressed below the base, very minutely punctured.

15. **Aulacophora testacea**, *Fabr. Mant. Ins.* i. 1787, p. 87.

Oblonga, postice paullo ampliata, convexa, flava, nitida; labro, pectore abdomineque nigris; thorace vix pone medium transversim sulcato; elytris infra basin leviter depressis, tenuissime punctatis. Long. 3 lin.

***Mas.* Abdominis segmenti analis lobo intermedio transverso-quadrato, plano.**

***Fœm.* Abdominis segmento anali rotundato, integro.**

Hab. India (*Fabr.*); Assam (*Chennell*: coll. *Baly*).

Labrum shining black; antennæ entirely flavous. Thorax nearly twice as broad as long; sides nearly straight and slightly diverging from the base to beyond the middle; disk transversely sulcate immediately behind the middle, the sulcation straight. Elytra slightly but distinctly depressed below the basilar space, very minutely punctured. Hinder femora in the male slightly stained on their outer surface with piceous.

The entirely black abdomen, together with the entirely different structure of the anal segment of the abdomen, will at once separate this species from *A. foveicollis* and *A. abdominalis*, with which insects it is usually confounded; it also differs from both in the depression below the basilar space of the elytra.

16. **Aulacophora flaviventris. Late ovata, postice ampliata, convexa, nigra, nitida, pectore piceo, abdomine antennisque (articulo basali excepto) pallide flavis; thorace lævi, ad latera minute punctato, sulco transverso, fere recto, sat fortiter impresso; elytris convexis, infra basin transversim excavatis, minute punctatis. Long. 4 lin.**

***Mas.* Abdominis segmento anali trilobato, lobo intermedio transverso-quadrato, plano, angulis anticis obtusis.**

***Fœm.* Abdominis segmento anali obtuso, leviter sinuato.**

Hab. Malay Peninsula, Penang, Tringano, Malacca.

Antennæ from the second to the tenth joint slender, filiform (the terminal joint broken off). Thorax nearly twice as broad as long; sides nearly straight and slightly diverging from the base to beyond the middle, thence obliquely converging towards the apex; upper surface smooth, very finely punctured on the sides; discoidal sulcation nearly straight, deeply impressed. Elytra much broader than the thorax, dilated posteriorly; convex, transversely excavated below the basilar space, very minutely punctured.

Similar in form to *A. lata*, differing in the colour of the thorax and lower surface of the body, which is uniform in the three specimens (two males and one female) before me; the sides of the thorax are also straight posteriorly, instead of rounded as in the former species.

17. AULACOPHORA ABDOMINALIS, *Fabr. Spec. Ins.* i. p. 151.

Oblonga, postice paullo ampliata, convexa, flava, nitida, antennis extrorsum, pectore abdomineque (ano excepto) nigris; thorace transversim sulcato, sulci medio magis profunde impresso. Long. 3½ lin.

Mas. **Abdominis segmenti analis lobo intermedio oblongo, profunde longitudinaliter concavo.**

Hab. Islands of the Pacific Ocean (*Fabr.*); Western Australia (*my collection*).

Very similar in general appearance to *A. foveicollis*, Küst., the thorax less deeply excavated on the middle disk, the outer half of the antennæ black. I only know the male of this species.

18. AULACOPHORA FABRICII. **Anguste subelongato-ovata, postice paullo ampliata, convexa, flava, nitida, antennis (basi exceptis), pedibus posticis quatuor, pectore abdomineque (hujus apice excepto) nigris; thorace transversim sulcato, sulco in mare disci medio magis profunde excavato; elytris tenuiter punctatis. Long. 3–3½ lin.**

Mas. **Antennarum articulo basali incrassato, abdominis segmento anali trilobato, lobo intermedio alteris longiore, sat profunde concavo-excavato.**

Fœm. **Abdominis segmento anali apice sinuato.**

Hab. Tonga Islands.

Antennæ filiform, nearly three fourths the length of the body, the basal joint in the male strongly thickened. Thorax nearly twice as broad as long; sides nearly straight and slightly diverging from the base to beyond the middle, thence rounded and converging towards the apex; disk transversely excavated, the sulcation in the male more broadly and deeply excavated on the middle disk. Elytra narrowly oblong, slightly dilated posteriorly, very finely punctured.

Separated from *A. nigroscutata* by the flavous scutellum and by the thoracic sulcation extending entirely across the disk; the apical abdominal segment in the female is also differently formed.

19. AULACOPHORA NIGROSCUTATA. **Anguste oblonga, postice paullo ampliata, convexa, flava, nitida, pectore, abdomine scutelloque nigris; thorace transverso, disci medio transversim excavato, sulco utrinque abbreviato; elytris tenuiter punctatis. Long. 3 lin.**

Mas. **Thoracis sulco profunde impresso; abdominis segmento anali trilobato, lobo intermedio profunde excavato.**

Fœm. Abdominis segmento anali apice rotundato, medio processu oblongo retrorsum producto armato; pygidio apice emarginato.

Hab. Gilolo; Amboyna (*Wallace*).

Antennæ filiform. Thorax nearly twice as broad as long; sides parallel from the base to beyond the middle; disk convex, deeply impressed with a large transverse excavation, which terminates on either side some distance before reaching the lateral margin; this excavation is less deeply impressed in the female; in this sex on either side, between the excavation and the lateral border, is a small fovea. Elytra oblong, dilated posteriorly, convex, finely and rather closely punctured.

20. AULACOPHORA WALLACII. Subelongato-ovata, postice ampliata, convexa, flava, nitida, pectore abdomineque nigris, scutello femoribusque posticis quatuor nigro-piceis; thorace transversim sulcato; elytris subnitidis, minute punctatis. Long. 4 lin.

Mas. Thoracis sulco medio profunde excavato; antennis filiformibus, articulo primo sat valde incrassato; abdominis segmento anali trilobato, lobo intermedio oblongo, profunde excavato.

Fœm. Abdominis segmento anali apice emarginato, incisura transverso-quadrata, basi angulato-producta.

Hab. Timor (*Wallace*).

Antennæ filiform, about four fifths the length of the body, basal joint strongly thickened in the male; anterior half of labrum nigro-piceous. Thorax nearly twice as broad as long; sides more or less distinctly sinuate and slightly diverging from the base to beyond the middle, thence obliquely rounded towards the apex; upper surface finely but distinctly punctured on the sides, impressed across the middle with a nearly straight transverse sulcation, which is of nearly equal depth for its whole course in the female, but which is much broader and more deeply excavated on the middle disk in the male. Elytra subnitidous, not distinctly excavated below the basilar space, minutely punctured.

This insect in coloration closely resembles *A. similis*, but the four posterior thighs alone are nigro-piceous, the middle disk of the thorax is more deeply excavated in the male, and the emargination at the apex of the abdomen in the female is of an entirely different form. I only know three specimens, two males and one female, all from Timor.

21. AULACOPHORA CORNUTA, *Baly, Cist. Ent.* ii. p. 445.

Oblonga, postice paullo ampliata, convexa, flava, labro, pectore abdomi-

neque nigris; thorace transversim sulcato; elytris tenuiter punctatis. Long. 3½–4 lin.

Var. A. Elytris nigro-piceis, anguste flavo-limbatis.

A. robusta, *Duviv. Notes Leyd. Mus.* vi. p. 124.

Mas. Antennarum articulo basali incrassato, intus compresso, carinato; fascie utrinque infra antennas tuberculo compresso, subconico, medioque lamina brevi, pube nigro circumdata, instructa; telo apice hastato; abdominis segmento anali trilobato, lobo intermedio profunde longitudinaliter sulcato.

Fœm. Abdominis segmento anali late concavo-emarginato, emarginationis medio dente brevi instructo.

Hab. Assam; Siam (*Mouhot*); Celebes; Ceram; Timor; Sulu Islands; Flores (*Wallace*); var. A, Wagaiou (*Wallace*); New Guinea (*v. Rosenberg*).

Antennæ filiform. Thorax twice as broad as long; sides rounded, nearly straight at the base; upper surface deeply grooved just behind the middle, the sulcation nearly straight. Elytra oblong, slightly dilated posteriorly, convex, not depressed below the basilar space, finely punctured.

Var. A at first sight is very dissimilar to the type, and has been described by M. Duvivier as a separate species; it agrees, however, so closely in structural characters that I cannot but place it under the same specific head.

22. AULACOPHORA FOVEICOLLIS, *Küster, Käf. Eur.* xxviii. p. 100.

Oblonga, postice paullo ampliata, convexa, flava, nitida, pectore abdomineque (ano excepto) nigris; thorace transversim sulcato, sulco medio angulato, magis fortiter excavato; elytris tenuissime punctatis. Long. 3–3½ lin.

Mas. Antennarum articulo basali incrassato; thoracis sulco medio ampliato et profunde excavato et margine postico utrinque tuberculo conico instructo; abdominis segmento anali trilobato, lobo intermedio oblongo, profunde longitudinaliter concavo.

Fœm. Abdominis segmento anali apice breviter sinuato; disco utrinque concavo-excavato, pygidio apice emarginato.

Hab. Southern Europe; Northern Africa; India.

The peculiar sculpture of the thorax, combined with the form of the anal segment of the abdomen in either sex, will distinguish this species at once from its congeners.

23. AULACOPHORA SIMILIS, *Oliv. Ent.* vi. p. 624, pl. 2. f. 23.

A. femoralis, *Motsch. Etud. Ent.* 1857, p. 37.

Elongato-ovata, postice ampliata, flava, nitida, pectore abdomineque (ano flavo plerumque excepto) nigris; pedibus posticis quatuor plus minusve nigris; thorace transversim sulcato, sulco medio sinuato; elytris tenuiter sat crebre punctatis. Long. 3–3½ lin.

Var. A. Pedibus flavis.

Rhaphidopalpa flavipes, *Jac. Notes Leyden Mus.* v. p. 202.

Mas. Thoracis sulco transverso medio profunde excavato; abdominis segmento anali trilobato, lobo intermedio oblongo, profunde longitudinaliter excavato.

Fœm. Abdominis segmento anali bilobato, lobis concavis.

Hab. Mantchuria; Japan; Northern India, China; Canton; Cochin China; Malay Archipelago.

The male of the present species is very similar in form and in the structure of the anal abdominal segment to the same sex of *A. foveicollis* and of *A. abdominalis*; the four hinder legs are usually stained more or less with nigro-piceous, although in some specimens from Canton they are entirely flavous; it may be known, however, by the thorax being less deeply excavated. The female is at once distinguished by the deeply bilobate anal segment of the abdomen.

This species is very widely spread, and is often confounded in collections with *A. coffeæ*, Hornst.

24. AULACOPHORA TETRASPILOTA. Elongato-ovata, postice ampliata, pallide flava, nitida; pectore abdomineque nigris; thorace lateribus rotundatis, basi fere rectis, disco transversim sulcato; elytris tenuiter punctatis, utrisque puncto subbasali maculaque transversa pone medium, nigris. Long. 2½ lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio oblongo, profunde concavo.

Fœm. Abdominis segmento anali apice obtuse truncato.

Hab. Batchian; Amboina; Gilolo (*Wallace*).

Antennæ filiform, equal to the body in length in the male. Thorax about one half broader than long; sides rounded, nearly straight from the base to beyond the middle; disk rather deeply transversely sulcate. Elytra finely but distinctly punctured; each elytron with a small round spot immediately below the middle of the basal margin, together with a second, transverse, placed obliquely a short distance below the middle, black.

25. AULACOPHORA OCTOMACULATA. Late ovata, postice ampliata, convexa, pallide flava, nitida; pectore abdominisque segmentorum maculis (his triseriatim dispositis) nigris; thorace lateribus a basi fere ad apicem subrectis, angulis acutis, disco utrinque transversim excavato; elytris tenuiter sed distincte punctatis; utrisque maculis quatuor (2, 2 transversim dispositis) nigris. Long. 3 lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio oblongo-quadrato, concavo.

Fœm. Abdominis segmento anali apice obtuso.

Hab. Northern India.

Eyes black, vertex with two small piceous spots, sometimes obsolete; antennæ filiform. Thorax about one half broader than long; sides slightly diverging, and almost straight from the base nearly to the apex; the anterior and posterior angles acute; upper surface broadly and deeply excavated transversely on either side, the excavation extending nearly across the entire disk. Elytra subquadrate-ovate, dilated posteriorly; moderately convex, distinctly but not very closely punctured; each elytron with four large black patches, placed obliquely in pairs, two at the base and two below the middle; of the upper pair the first, near the suture, is attached to the basal margin, the other is placed just below the humeral callus; the outer one of the lower pair is attached to the lateral margin.

26. AULACOPHORA EXCAVATA. Oblongo-ovata, postice paullo ampliata, flava, nitida; thoracis disco sat profunde excavato; elytris subnitidis, tenuiter subcrebre punctatis, nigro-cyaneis; tibiis apice tarsisque infuscatis. Long. 4½–5 lin.

Mas. Abdominis segmento anali profunde trilobato, lobo intermedio alteris paullo longiore, oblongo, apice truncato, concavo.

Fœm. Abdominis segmento anali bilobato, lobis apice incurvatis, pygidio apice angulato-emarginato.

Hab. India.

Antennæ filiform. Thorax about one half broader than long; sides nearly parallel and slightly sinuate from the base nearly to the apex; middle disk deeply excavated transversely, the hinder margin of the excavation obsoletely trisinuate. Elytra finely punctured.

Nearly allied to *A. impressa*, Fabr., its thorax less deeply excavated, the excavation different in form, the elytra unicolorous, and the under surface of the body entirely flavous.

27. AULACOPHORA COFFEÆ, *Hornst. Schrift. Berl. Ges.* viii. 1788, p. 5, t. i. f. 7.

Aulacophora varians, var. B?, *Chapuis, Ann. Soc. Ent. Belg.* t. xix. p. c.

Subelongata, postice paullo ampliata, convexa, sordide flava, nitida; oculis magnis; pectore, abdomine pedibusque nigris, vertice plus minusve, clypei margine antice labroque nigro-piceis; scutello piceo; thorace lævi, sat profunde transversim sulcato; elytris minute punctatis, subnitidis. Long. 3½–4 lin.

Var. A. Pedibus anticis flavis.

Mas. Abdominis segmento anali trilobato, lobo intermedio quadrato, plano.

Fœm. Abdominis segmento anali integro, obtuso.

Hab. Java; Sumatra; Philippine Islands; Tondano; Tringano; Cambodia; India.

Antennæ filiform, equal to the body in length in the male, rather shorter in the female; anterior margin of clypeus, together with the entire labrum, nigro-piceous; vertex also stained more or less with the same colour. Thorax about one half broader than long; sides very slightly diverging and obsoletely sinuate from the base to beyond the middle, thence converging and slightly rounded towards the apex; disk smooth, deeply impressed transversely immediately behind the middle, the sulcation nearly straight. Elytra convex, not excavated below the basilar space, minutely punctured.

This species closely resembles *A. bicolor* in general form and in the structure of the anal segment of the abdomen in both sexes; in addition, however, to the uniform coloration of the elytra, the nigro-piceous labrum and anterior margin of the clypeus will separate it from all the varieties of that species.

28. AULACOPHORA BICOLOR, *Weber, Obs. Ent.* 1801, p. 56; *Fabr. Syst. El.* i. p. 482.

Subelongata, postice paullo ampliata, convexa, nigra, nitida; capite, thorace scutelloque flavis aut fulvis; pedibus anticis femoribusque intermediis sordide flavis, plus minusve piceo tinctis; elytris opacis, nigris, macula parva basali apiceque fulvis. Long. 4–5 lin.

Var. A. Corpore subtus toto fulvo.

Var. B. Elytris nigris, apice marginibus laterali et suturali et interdum fascia interrupta prope medium fulvis.

Var. C. Elytris rufo-fulvis, dimidio apicali et utrisque maculis duabus infra basin, nigris; pedibus anticis quatuor fere totis sordide fulvis.

Var. D. Elytris fulvis, utrisque maculis transversis irregularibus duabus, una ad basin, altera vix pone medium positis, nigris; pedibus ut in typo.

Var. E. Elytris flavis aut fulvis, utrisque maculis duabus, infra basin transversim positis, fasciaque transversa vix pone medium, utrinque abbreviata, nigris.

Aulacophora sexnotata, *Chapuis, Ann. Soc. Ent. Belg.* t. xix. p. c.

Var. F. Corpore flavo, oculis nigris.

Var. G. Minor; corpore flavo, elytris nitidis.

Mas. Abdominis segmento anali trilobato, lobo intermedio quadrato, leviter concavo.

Fœm. Abdominis segmento anali integro, obtuso.

Hab. Type, Sumatra, Java; var. A, Celebes, Gilolo, Flores; var. B, C, and D, Java; var. E, Java, Philippines, Lombock; var. F, Ceylon; var. G, Celebes.

The above species is very nearly allied to *A. coffeæ*, Hornst., agreeing closely in form and structural characters. The head in the male of the present insect is narrow and the eyes are larger and more prominent, and the apical surface of the intermediate lobe of the anal segment of the abdomen is slightly concave instead of plane. *A. bicolor*, however, although extremely variable in coloration, always has the lower edge of the clypeus and the entire labrum concolorous with the upper face; in *A. coffeæ*, on the contrary, these parts are nigro-piceous or black.

29. AULACOPHORA NIGRIVESTIS, *Boisd. Voy. de l'Astrol.* p. 548.

Subelongata, postice paullo ampliata, convexa, fulva, nitida; tibiis apice, tarsis antennarumque articulis intermediis piceis; abdomine elytrisque nigris, his æneo tinctis; thorace lateribus a basi fere ad apicem rectis, disco sat fortiter transversim sulcato, sulco utrinque magis distincte impresso. Long. $3\frac{4}{5}$ lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio alteris longiore, transverso-quadrato, plano, apice truncato.

Hab. Fiji Islands, a single specimen.

Antennæ nearly equal to the body in length, slender, filiform. Thorax nearly twice as broad as long; sides straight and parallel, obliquely converging near the apex. Elytra narrowly oblong, slightly dilated posteriorly, convex, distinctly punctured. Extreme apex of the abdomen piceous.

30. AULACOPHORA DOWNESI. Ovata, postice ampliata, nigra, nitida, capite, thorace, scutello pedibusque flavis; thorace lateribus ante medium obtuse angulatis, disco modice transversim sulcato; elytris tenuiter punctatis, plaga magna basali, trigonata, communi, flava. Long. $2\frac{3}{4}$–3 lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio late oblongo-quadrato, plano.

Fœm. Abdominis segmento anali apice sinuato.

Hab. India, Bombay (*Dr. Ezra Downes*).

Antennæ filiform. Thorax about one half broader than long; sides obtusely angulate before the middle, nearly straight posteriorly; upper surface transversely sulcate, the sulcation less deeply impressed than in most other species of the genus. Elytra dilated posteriorly, moderately convex, very finely punctured.

In the two specimens before me the flavous patch on the elytra varies in extent.

31. **AULACOPHORA ANTENNATA.** Anguste ovata, postice ampliata, convexa, rufo-fulva, nitida; antennis flavis, pectore rarius pedibusque piceis; elytris convexis, infra basin prope suturam transversim excavatis, nigris, tenuissime punctatis; thorace lævi, sat profunde transversim sulcato. Long. 4–4½ lin.

Mas. Antennarum articulo ultimo incrassato, apice oblique sinuato-emarginato, dente acuto armato; abdominis articulo anali trilobato, lobo intermedio transverso-quadrato, disco concavo.

Fœm. Antennarum articulo ultimo non incrassato, abdominis segmento anali late truncato, obsolete sinuato.

Var. A. Pedibus fulvis.

Hab. Java; Singapore; Borneo, Sarawak (*Wallace*).

Antennæ filiform, the apical joint in the male thickened, its apex obliquely emarginate and armed with a short acute tooth; labrum and mouth concolorous with the upper face. Thorax nearly twice as broad as long; sides nearly straight and very slightly diverging from the base to just beyond the middle, thence obliquely converging towards the apex, anterior angle obliquely truncate, armed laterally with a small obtuse tooth; upper surface smooth, with a few scattered punctures on either side behind the anterior angle; transverse groove nearly straight, deeply impressed. Elytra dilated posteriorly, convex, transversely excavated below the basilar space, minutely but not closely punctured.

32. **AULACOPHORA LUTEICORNIS,** *Fabr.*

Late ovata, postice ampliata, thorace sat profunde transversim sulcato, lateribus obtuse rotundatis; elytris tenuissime punctatis. Long. 4 lin.

Var. A. Nigra, nitida; thoracis lateribus angustis antennisque pallide flavis; elytris rufis, apice nigris; tarsis interdum rufo-piceis.

Var. B. Thoracis lateribus disco concoloribus, cæteris ut in var. A.

Galeruca luteicornis, *Fabr. Syst. El.* i. p. 482.

Var. C. Elytris totis rufis, cæteris ut in varr. A et B.

Aulacophora simplicipennis, *Clark, Ann. & Mag. Nat. Hist.* ser. 3, xv. 1865, p. 145.

Var. D. Nigra, antennis (basi exceptis) pallide flavis.

Var. E. Tota flava.

Mas. Antennarum articulo ultimo incrassato, apice emarginato; abdominis segmenti analis lobo intermedio plano, transverso-quadrato angulis anticis obtusis.

Fœm. Abdominis segmento anali transversim emarginato, trilobato, lobo intermedio brevi, truncato, lobis lateralibus subacutis, apice incurvatis.

Hab. Malay Peninsula, Singapore, Penang, Tringano, Malacca; Borneo, Sarawak; Sumatra (*Wallace*).

This variable insect in point of coloration is, owing to the dilated apical joint of its antennæ in the male and to the peculiar emargination of the anal segment of the abdomen in the female, one of the best defined species of the genus; the formation of the anal segment of the abdomen will at once distinguish the latter sex from all others known to me of the genus. *Aulacophora antennata*, described in the present paper, is the only insect with which the male can be confounded; in the male of *A. antennata* the body is larger and narrower, the dilated apical joint of its antennæ is differently notched at the apex, and the intermediate lobe of the anal segment is concave, not plane as in *A. luteicornis*. The apical segment of the abdomen in the female of *A. antennata* is not emarginate.

33. **Aulacophora Stevensi.** Anguste ovata, convexa, pallide flava, nitida, scutello nigro-piceo, oculis nigris; thorace transversim sulcato; elytris tenuissime punctatis, basi extrema, sutura, apice, nec non linea submarginali, a basi fere ad apicem extensa, nigris. Long. 3½–4 lin.

Mas. Antennarum articulis 3^{o}–5^{m} incrassatis; abdominis segmento anali trilobato, lobo intermedio oblongo-quadrato, profunde concavo.

Fœm. Antennis filiformibus; abdominis segmento anali apice sinuato.

Hab. Ceylon; India, Dinapore.

Front impressed on either side with an oval fovea in the male. Antennæ in the same sex with the second joint very short, turbinate, the following three thickened; the third compressed, trigonate, its antero-external angle very acute; the fourth more strongly thickened, oblong-ovate; the fifth slightly compressed, subtrigonate, its outer edge armed near the apex with a short acute tooth, its upper surface excavated.

34. **Aulacophora Duboulayi.** Anguste oblonga, postice paullo ampliata, convexa, flava aut fulva, nitida, collo utrinque nigro, tibiis ad apicem tarsisque nigro-piceis; thorace transversim sulcato; elytris tenuissime, subcrebre punctatis, viridi-æneis. Long. 3–3½ lin.

Mas. Antennarum articulis tertio ad sextum dilatatis, fronte utrinque intra oculum foveolata; abdominis segmento anali trilobato, lobo intermedio oblongo-quadrato.

Fœm. Antennis filiformibus nigris, basi fulvis; abdominis segmento anali apice leviter sinuato.

Hab. Western Australia (*Duboulay*).

Upper portion of front in the male impressed just within the eye with a large round fovea; antennæ in the same sex entirely flavous, the second joint very short, moniliform, the third thickened, subtrigonate, its antero-external angle armed with a long acute tooth, the fourth joint strongly thickened, compressed externally, equal in length to the third, the fifth shorter than either of the preceding, compressed and dilated externally at the base; antennæ in the female simple, filiform. Thorax transverse, transversely sulcate, more deeply excavated on either side the median line; its surface smooth, impunctate; sides nearly straight and parallel, slightly converging anteriorly. Elytra narrowly oblong, parallel, very finely punctured.

This species is separated from *A. smaragdipennis*, Duv. (*viridipennis*, Chap.), by the dilated joints of the antennæ in the male sex.

Females of which the males are unknown to me.

35. AULACOPHORA UNICOLOR, *Jac. Notes Leyd. Mus.* v. p. 201.

Ovata, postice ampliata, convexa, flava, nitida; thorace sat profunde transversim sulcato; elytris infra basin transversim depressis, tenuiter punctatis. Long. 5 lin.

Fœm. **Abdominis segmento anali integro.**

Hab. Saleyer.

This insect, of which Mr. Jacoby has kindly sent me a specimen, exactly resembles *A. Boisduvali* in size, form, and sculpture, only differing in the uniform flavous coloration of the whole body; whether it is a distinct species or only a local form of *A. Boisduvali* it is impossible, in the absence of the male (which is at present unknown), to determine.

36. AULACOPHORA NIGROSIGNATA. **Anguste ovata, postice ampliata, flava, nitida; pectore abdomineque nigris; thorace transversim sulcato, sulco medio subinterrupto; elytris subnitidis, tenuiter punctatis, utrisque plaga basali transversa, utrinque abbreviata, fasciaque pone medium, interdum ad suturam abbreviata, nigris. Long. 4–4½ lin.**

Fœm. **Abdominis segmento anali apice integro, obtuso.**

Hab. Flores (*Wallace*).

Antennæ nearly three fourths the length of the body, filiform. Thorax nearly twice as broad as long; sides nearly straight and slightly diverging from the base to beyond the middle, thence converging towards the apex; upper surface finely but distinctly punctured on either side in front; disk deeply sulcate transversely, the sulcation less deeply impressed in its middle. Elytra subnitidous, minutely punctured; on each elytron are several faint longitudinal sulcations.

37. **Aulacophora Lewisii.** Anguste ovata, postice ampliata, convexa, rufo-fulva, nitida; abdomine nigro-piceo; thorace vix pone medium transversim sulcato; elytris nigris, infra basin non excavatis, minute punctatis. Long. 3 lin.

Fœm. Abdominis segmento anali integro.

Hab. China, Hongkong (*Lewis*).

Thorax nearly twice as broad as long; sides nearly straight and parallel from the base to beyond the middle, thence converging towards the apex; disk smooth, impressed just behind the middle with a nearly straight transverse sulcation. Elytra not depressed transversely below the basilar space, minutely punctured.

At first sight very close to *A. nigripennis*, but at once to be known by the different coloration of the under surface of the body, by the pale legs, and by the absence of the subbasilar depression on the elytra. Although from so widely different a locality, it is just possible that this insect may be the female of *A. nigrivestis*, Boisd.

38. **Aulacophora semilimbata.** Anguste oblongo-ovata, convexa, flava, nitida; antennis (basi exceptis), tibiis apice tarsisque nigro-piceis; abdomine piceo tincto; thorace profunde transversim sulcato; elytris convexis, infra basin excavatis, nigris, nitidis, limbo suturali, nec non margine externo, his ante medium obsoletis, flavis. Long. $3\frac{3}{4}$ lin.

Fœm. Abdominis segmento anali obtuso, obsolete sinuato.

Hab. New Guinea, Dorey (*Wallace*).

Antennæ slender, filiform, the basal joint flavous. Thorax nearly twice as broad as long; sides distinctly angulate; disk transversely impressed with a deep sulcation, which is rather more strongly excavated on either side the median line. Elytra oblong, slightly dilated posteriorly; convex, distinctly excavated on the suture below the basilar space, shining, impunctate.

39. **Aulacophora Duvivieri.** Anguste ovata, postice paullo ampliata, convexa, flava, nitida; pectore, abdomine pedibusque posterioribus nigris, anticis piceis; thorace quam longo fere duplo latiore, transversim sulcato, sulco prope marginum fere obsoleto; elytris minute punctatis. Long. 4 lin.

Var. A. Tibiis tarsisque intermediis piceis.

Fœm. Abdominis segmento anali apice late emarginato, leviter bisinuato.

Hab. Java; Malacca.

Antennæ filiform; labrum concolorous with the upper face. Thorax nearly twice as broad as long; sides nearly straight and parallel from the base to beyond the middle, thence obliquely converging towards the apex; disk transversely excavated across the middle, the sulcation nearly obsolete near the lateral margin. Elytra narrowly oblong, slightly dilated posteriorly, convex, not excavated below the basilar space, minutely punctured.

40. **AULACOPHORA EXCISA.** Ovata, postice ampliata, convexa, flava, nitida; pectore abdomineque (hoc apice excepto) nigris; femoribus posticis quatuor piceo-nigris; thorace sat profunde transversim sulcato; elytris minute punctatis. Long. 3⅓ lin.

Var. A. Antennis extrorsum pedibusque posticis quatuor nigris, pedibus anticis piceo tinctis.

Fœm. Abdominis segmento anali apice bilobato, lobis planis, ad apicem incurvatis.

Hab. Celebes; Flores; var. A, New Guinea (*Wallace*).

Antennæ slender, filiform, nearly two thirds the length of the body, the outer half slightly stained with piceous; labrum piceous. Thorax transverse; sides nearly straight and parallel from the base to beyond the middle, thence converging towards the apex, the posterior angle obtuse; disk deeply impressed across the middle with a transverse groove. Elytra minutely, but not closely punctured. Apical lobes of abdomen plane, separated by a broad deep incision.

The peculiar form of the apical segment of the abdomen in the female (the only sex known to me) will at once separate this species from its allies.

41. **AULACOPHORA MOUHOTI.** Anguste ovata, postice ampliata, convexa, flava, nitida; pectore abdomineque nigris, scutello nigro-piceo; thorace sat profunde transversim sulcato; elytris minute subcrebre punctatis. Long. 3 lin.

Fœm. Abdominis segmento anali trilobato, lobis æquilongis, intermedio apice emarginato.

Hab. Cochin China; Malacca.

Antennæ slender, filiform, more than half the length of the body, stained with piceous. Thorax transverse; sides nearly straight and parallel from the base to just beyond the middle; disk deeply transversely sulcate. Elytra minutely punctured.

The above insect, of which I know only the female, agrees with *A. luteicornis* in the anal segment of its abdomen being trilobate, but differs in the narrower form and in the intermediate anal lobe being nearly equal in length to the lateral ones.

42. **AULACOPHORA COSTATIPENNIS.** Ovata, postice ampliata, convexa, rufo-fulva, nitida; thorace sat profunde transversim sulcato, lateribus angulatis; elytris infra basin leviter transversim depressis, nigris, elevato-vittatis, interspatiis punctatis. Long. 3½ lin.

Fœm. Abdominis segmento anali apice obtuso.

Hab. ——? A single specimen, my collection.

Antennæ slender, filiform. Thorax nearly twice as broad as long; sides straight and diverging from the base to beyond the middle, thence obliquely converging towards the apex; disk minutely punctured on either side, deeply transversely sulcate. Elytra broadly ovate, dilated posteriorly, convex, slightly depressed transversely below the basilar space; each elytron with nine distinctly elevated longitudinal costæ, their interspaces minutely punctate.

Nearly allied to *A. Batesi*, Jac., and *A. anchora*, Redt.; its elytra nitidous, entirely black, and distinctly depressed below the basilar space.

Genus PSEUDOCOPHORA, *Jacoby*.

PSEUDOCOPHORA BRUNNEA. Ovata, postice ampliata, valde convexa, pallide fulvo-picea, nitida, pectore, abdomine pedibusque posterioribus quatuor nigris; thorace leviter transversim sulcato, lateribus angulatis; elytris distincte punctatis. Long. 3 lin.

Hab. Celebes (*Wallace*).

Antennæ filiform. Thorax rather more than one half broader than long; sides distinctly produced and angulate before the middle; disk impressed transversely with a shallow sulcation. Elytra broadly oblong-ovate, dilated posteriorly, convex, distinctly punctured, the puncturing nearly obsolete on the hinder disk.

In the typical species of the genus, as well as in the present one, the prosternum is distinct and nearly equal in height to the coxæ; this character is not mentioned by Mr. Jacoby.

Genus PARIDEA.

Corpus ovatum, postice ampliatum. *Caput* exsertum; *oculis* rotundatis, integris; *antennis* filiformibus. *Thorax* transverso-quadratus, dorso transversim sulcatus. *Elytrorum epipleura* a basi ad medium extensa. *Pedes* simplices; *tibiis* apice spina brevi armatis; *tarsis posticis* articulo basali ad duos sequentes æquilongo; *unguiculis* appendiculatis. *Prosternum* coxis anticis occultum; *acetabulis* anticis apertis.

Type *Paridea thoracica*.

Closely resembling *Aulacophora* in general form, separated by the prolonged elytral epipleura and by the appendiculated claws.

PARIDEA THORACICA. Ovata, postice ampliata, convexa, flava, nitida; pectore abdominisque maculis nigris; capite thoraceque rufo-fulvis; antennis (basi exceptis) nigro-piceis; thorace quam longo latiore, lateribus fere parallelis, sinuatis, disco profunde transversim excavato; elytris tenuiter sed distincte punctatis, utrisque plaga basali subrotundata, alteraque pone medium, transversa, nigris. Long. 2½ lin.

Fœm. Abdominis segmento anali integro, obtuso.

Hab. India.

Antennæ rather slender, filiform. Thorax about one fourth broader than long; sides parallel and rather deeply sinuate from the base to beyond the middle, very slightly dilated before the latter; disk smooth, broadly and deeply excavated transversely, more deeply excavated on either side. Elytra dilated posteriorly, finely but distinctly punctured. Abdominal segments stained with black on either side.

Genus ÆNIDEA, *Baly*.

ÆNIDEA FACIALIS. Elongata, flavo-fulva, nitida; thorace lævi, disco leviter transversim excavato; lateribus a basi ad ultra medium divergentibus, hinc ad apicem rotundato-convergentibus; elytris parallelis, puncto humerali suturaque basi, nigris. Long. 4 lin.

Mas. Facie infra antennas lamina transversa trigonata, antrorsum producta armata; clypeo transverso, tumido, apice superiori bispinoso; antennarum articulo tertio subtus emarginato.

Hab. Ceylon.

Clypeus in the male transversely swollen, its anterior border emarginate, its upper edge free, bispinose; face below the antennæ armed with a large, transverse, horizontal, triangular plate, its apex acute; antennæ in the same sex robust, the third joint sinuate beneath. Thorax about one half broader than long; sides straight and diverging from the base to beyond the middle, thence converging towards the apex. Elytra finely punctured.

A Synopsis of the Genera of the *Chalcididæ*, Subfamily *Eucharinæ*; with Descriptions of several new Genera and Species of *Chalcididæ* and *Tenthredinidæ*. By W. F. Kirby, Assistant in the Zoological Department, British Museum. (Communicated by Dr. J. Murie, F.L.S.)

[Read 17th June, 1886.]

(Plate I.)

Synopsis of the Genera of Eucharinæ.

I have here attempted to give a generic revision of the subfamily *Eucharinæ*, which includes some of the most beautiful and remarkable species of the Chalcididæ. With few exceptions, the species are extra-European, and appear to be most numerous in Tropical America and Australia. The species in the British Museum represent at least fifteen well-marked genera, of which only ten have been previously characterized. I have selected only the most salient characters of each genus; for minute and detailed characters are unnecessary in the present imperfect state of our knowledge of the subfamily.

The Eucharinæ are large, strongly-sculptured, metallic-coloured Chalcididæ; the abdomen is always more or less petiolated, and is frequently raised and compressed, giving the insects some resemblance to the Cynipidæ. From the *Perilampinæ*, to which they have some resemblance, they may be distinguished by the longer petiole, the absence of the stigmatic nervule, &c.

List of Genera of Eucharinæ, *with indication of Types, and characters of new Genera.*

1. Eucharis, *Latr.*, *Hist. Nat. Crust. Ins.* xiii. p. 210 (1805).

Type, Cynips adscendens, *Fabr.*

Cynips adscendens, *Fabr. Mant. Ins.* i. p. 251. n. 1 (1787).

Eucharis Kollari, *Först. Verh. Ver. Rheinl.* xvi. p. 91. n. 25 (1859).

Details: *Westw. Thes. Ent. Oxon.* pl. xxviii. f. 15, *a–d* (1874).

Hab. Europe.

Panzer (Faun. Germ. Heft 88, pl. 10) represents the legs as yellow, saying only "antennæ tarsorumque ungulæ nigræ;" and his insect thus appears to differ from that of Fabricius, who says "pedes pallide femoribus basi nigris." Förster regarded them as distinct; and as Fabricius merely gave a brief diagnosis in his Syst. Piez. p. 157, and this apparently founded on Panzer's figure, Förster was not unnaturally misled into redescribing and renaming the Fabrician instead of the Panzerian insect.

2. ORASEMA, *Cameron*,
Biol. Centr.-Amer., *Hym.* p. 104 (1884).

Type, ORASEMA FLAVIPES, *Cam.*

Orasema stramineipes, *Cam. l. c.* p. 105 (1884).

Orasema flavipes, *Cam. op. cit.* pl. v. figs. 20, 20 *a–c*, pl. vi. figs. 18, 18 *a–e* (1884).

Hab. Panama.

There seems to be some error about this species, as the description does not well agree with the figure. Judging by the figure, I would refer *Eucharis festiva*, Fabr., *E. rapo*, Walk., and *Schizaspidia maculata*, Westw., to this genus. All these are South-American insects.

3. TRICORYNA, gen. nov.

Male. Antennæ 11-jointed, thick, moniliform, striated and finely pubescent; scape short; second joint short and transverse; third joint four times as long as broad, much thickened beyond the middle; fourth narrower, longer than broad; the remainder gradually decreasing in length, but not in width, to the ninth; the tenth shorter and narrower than the ninth, and the eleventh minute. Head and thorax coarsely punctured, moderately pubescent; scutellum gibbous, but not produced; petiole longitudinally striated, moderately broad, about two thirds as long as the abdomen. Abdomen about four times as long as broad, tapering at both ends, and rather finely punctured; first joint of tarsi very thick, and much longer than all the rest put together.

Type, EUCHARIS IELLO, *Walk.*

Eucharis Iello, *Walk. Mon. Chalc.* ii. p. 12 (1839).

Details: *Haliday, Entomol.* i. pl. P. figs. 3, 3 *a*, *b* (1842).

Hab. Tasmania.

4. Metagea, gen. nov.

Male. Antennæ nearly naked; the third joint four times as long as broad, and gradually thickened to the extremity; the remainder thickened at the extremity, and gradually decreasing in length to the eighth, which is only slightly longer than broad; the rest broken off; petiole short. First joint of the tarsi as long or longer than all the rest together, but not thickened. Abdomen obtuse at tip.

Type, Eucharis Zalates, *Walk.*

Eucharis Zalates, *Walk. Mon. Chalc.* ii. p. 13 (1839).

Details: *Haliday, Entomol.* i. pl. P. figs. 4, 4 *a–c* (1842).

Hab. Australia.

5. Psilogaster, *Blanch.*,

Hist. Anim. Art. iii. p. 260 (1840); ? *Brullé, Ins. Hym.* iv. p. 573 (1846).

Type, Psilogaster cupreus, *Blanch.*

Psilogaster cupreus, *Blanch. l. c.* (1842).

Hab. Egypt.

Brullé has figured a Tasmanian insect to represent this genus (*P. pallipes*, Brullé, *l. c.* pl. xxxix. figs. 1 & 2), and the British Museum possesses many species congeneric with this from Australia and Tasmania. It is, however, very probable that the Egyptian insect may prove to be generically distinct from these, in which case the Australian group will require a new name.

6. Chalcura, gen. nov.

Male. Antennæ pubescent, 12-jointed; joints 3–11 throwing off a long pubescent ramus from the extremity on the outside. Scutellum gibbous, unarmed. Petiole moderately stout, about two thirds as long as the conical abdomen, and longitudinally striated.

Female with scarcely the rudiments of the antennal rami. Petiole short and broad. Abdomen oval. First joint of tarsi nearly as long as all the remainder, but not expanded.

Type, Eucharis deprivata, *Walk.*

Eucharis deprivata, *Walk. Ann. & Mag. N. H.* (3) vi. p. 359 (1860); *Westw. Thes. Ent. Oxon.* p. 155, pl. xxviii. fig. 6 (1874).

Hab. Ceylon.

7. RHIPIPALLUS, gen. nov.

Male. Antennæ pubescent, 13-jointed, with short joints; joints 4–12 throwing off long pubescent rami (thickened at the tips) from the outside, and shorter ones from the inside. Scutellum gibbous, unarmed. Petiole moderately slender, as long as the oval and moderately raised abdomen.

Type, EUCHARIS VOLUSUS, *Walk.*

Eucharis volusus, *Walk. Mon. Chalc.* ii. p. 9 (1839).

Details: *Haliday, Entomol.* i. pl. P. figs. 1, 1 *a–d* (1842).

Hab. Australia.

8. STILBULA, *Spin.*,
Ann. Mus. xvii. p. 150 (1811).

Type, ICHNEUMON CYNIPIFORMIS, *Rossi.*

Ichneumon cyniformis (*sic*), *Rossi, Mant. Ins.* p. 125, pl. vi. fig. G (1792).

Hab. S. Europe.

9. SCHIZASPIDIA, *Westw.*,
P. Z. S. 1835, p. 69.

Type, SCHIZASPIDIA FURCIFERA, *Westw.*

Schizaspidia furcifera, *Westw. l. c.* (1835); *Thes. Ent. Oxon.* p. 151, pl. xxviii. fig. 2 (1874).

Hab. India.

10. TETRAMELIA, gen. nov.

Male. Antennæ 12-jointed; joints 3–11 each throwing off a long pubescent ramus. Scutellum bidentate. Metathorax throwing off a stout horn-like process on each side, curving outwards horizontally nearly as far as the level of the petiole, which is slender and about as long as the height of the abdomen. The latter is of an irregular shape, elevated, compressed, and rather pointed in front, the first segment covering about half the abdomen.

Type, SCHIZASPIDIA PLAGIATA, *Walk.*

Schizaspidia plagiata, *Walk. Trans. Ent. Soc.* (3) i. p. 385 (1862); *Westw. Thes. Ent. Oxon.* p. 152, pl. xxviii. fig. 11 (1874).

Hab. Para.

11. LOPHYROCERA, *Cameron*,
Biol. Centr.-Amer., *Hym.* p. 103 (1884).

Types, LOPHYROCERA STRAMINEIPES and L. NIGROMACULATA, *Cam.*

(1) Lophyrocera stramineipes, *Cam. l. c.* pl. v. figs. 18, 18 *a* (1884).

Hab. Panama.

(2) Lophyrocera nigromaculata, *Cam. l. c.* p. 104, pl. v. figs. 19, 19 *a*, *b* (1884).

Hab. Nicaragua.

12. KAPALA, *Cameron*,
Biol. Centr.-Amer., *Hym.* p. 102 (1884).

Chirocerus, *Brullé* (*nec Latr.*), *Ins. Hym.* iv. p. 571 (1846).

Type, EUCHARIS FURCATA, *Fabr.*

Eucharis furcata *and* E. flabellata, *Fabr. Syst. Piez.* p. 158 (1804).

Thoracantha furcata, *Haliday*, *Entomol.* i. pl. P. figs. 2, 2 *a–c* (1842).

Kapala furcata, *Cam. l. c.* p. 103, pl. v. figs. 17, 17 *a–d* (1884).

Hab. South and Central America.

There are several species of this genus, from different parts of South America, in the British Museum. *Chirocerus furcatus*, Brullé (Ins. Hym. pl. xxxviii. figs. 5, 5 *a*, *b*, 1846), seems to me to agree better with *Thoracantha atrata*, Walk. (Trans. Ent. Soc. (3) i. p. 383, 1862), than with the Fabrician species.

13. THORACANTHA, *Latr.*,
Cuv. Règne Anim. ed. 2, v. p. 297 (1829).

Galearia, *Brullé*, *Spec. Hym.* iv. p. 572 (1846).

Type, THORACANTHA LATREILLII, *Guér.*

Thoracantha Latreillii, *Guér. Icon. Règne Anim.*, *Ins.* p. 415, pl. lxvii. fig. 8 (1829–44).

Thoracantha Latreillii *vel* coleopteroides, *Waterh. Trans. Ent. Soc.* ii. p. 196, pl. xvii. fig. 3 (1839).

Galearia violacea, *Brullé*, *l. c.* pl. xxxviii. figs. 6, 6 *a*, *b* (1846).

Hab. Brazil.

Although Latreille specified no type, yet his description clearly indicates this genus; moreover, *T. Latreillii* was figured and described as a *Thoracantha* before any other species to which the generic name could apply.

14. LIRATA, *Cameron*,
Biol. Centr.-Amer., *Hym.* p. 102 (1884).

Type, LIRATA LUTEOGASTER, *Cam.*

Lirata luteogaster, *Cam. l. c.* pl. v. figs. 16, 16 *a* (1884).

Hab. Panama.

15. UROMELIA, gen. nov.

Thoracantha, *Brullé* (*nec Latr.*), *Ins. Hym.* iv. p. 572 (1846).

Type, THORACANTHA STRIATA, *Perty.*

Thoracantha striata, *Perty*, *Del. Anim. Art.* p. 135, pl. xxviii. figs. 15, 16 (1834).

Hab. Amazons.

Table of Genera of Eucharinæ.

A. Scutellum not bidentate.
  B. Antennæ simple in male.
    C. Antennæ moniliform.
      D. Abdomen compressed, ascending ... 1. **Eucharis.**
      DD. Abdomen not compressed, nor ascending.
        E. First joint of tarsi much thickened .... 3. **Tricoryna.**
        EE. First joint of tarsi very long, but not thicker than the others 4. **Metagea.**
    CC. Antennæ not moniliform.
      F. Joints of antennæ long .... 5. **Psilogaster.**
      FF. Joints of antennæ short .... 2. **Orasema.**
  BB. Antennæ ramose in male.
    G. Antennæ ramose in male .... 6. **Chalcura.**
    GG. Antennæ biramose in male .... 7. **Rhipipallus.**
AA. Scutellum bidentate.
  H. Scutellum of moderate size.
    I. Antennæ simple in male .... 8. **Stilbula.**
    II. Antennæ ramose in male.
      K. Metathorax unarmed .... 9. **Schizaspidia.**
      KK. Metathorax with a strong lateral projection.
        L. Metathoracic processes curving downwards .... 11. **Lophyrocera.**
        LL. Metathoracic processes consisting of two diverging horizontal teeth 10. **Tetramelia.**
  HH. Scutellum often as long as the abdomen.
    M. Scutellar processes covering the whole abdomen.
      N. Scutellar processes very broad .... 13. **Thoracantha.**
      NN. Scutellar processes long, contiguous, and tapering to the extremity .... 15. **Uromelia.**
    MM. Scutellar processes long and slender, generally curving inwards towards the tips.
      O. Third joint of antennæ as long as all the rest together .... 14. **Lirata.**
      OO. Third joint of antennæ not much longer than fourth .... 12. **Kapala**

TENTHREDINIDÆ.

HYLOTOMINÆ.

1. **HEMIDIANEURA CAMERONI.** (Pl. I. fig. 10.)

Long. corp. 8 millim., exp. al. 20 millim.

Female. Head, antennæ, knees, tibiæ, tarsi, and abdomen (except base) black; thorax, base of abdomen, coxæ, trochanters, and femora (except tips) luteous; on the abdomen the five first ventral segments are luteous, but the first two dorsal segments only are wholly luteous, the sides of the third and fourth being clouded and shading into the deeper black of the following segments; wings purplish hyaline, with a strong smoky tinge, especially at the base.

Hab. Rio Grande do Sul (*Ihering*).

Not closely allied to any known species.

SELANDRIINÆ.

2. **SELANDRIA MERIDIONALIS.** (Pl. I. fig. 12.)

Long. corp. 6 millim., exp. al. 17 millim.

Female. Inky black; mesothorax above and front of scutellum dull red, prothorax yellower; wings smoky hyaline, with blackish-brown nervures, and a black dot in the second submarginal cell.

Hab. Rio Grande do Sul.

TENTHREDININÆ.

3. **MACROPHYA (?) SAUNDERSI.** (Pl. I. fig. 11.)

Long. corp. 11 millim., exp. al. 23 millim.

Female. Black; labrum, scutellum, a spot at the extremity of the hind coxæ, an oval spot on the side of the fifth and a round one on the side of the sixth segment yellow; coxæ otherwise black, four front femora and tibiæ yellowish red, the middle tibiæ just tipped with black; hind femora entirely red, except a small black spot at the extreme base; all the tarsi and the hind tibiæ black: wings iridescent hyaline, rather more clouded beyond the middle; nervures and stigma castaneous, the latter paler towards the base; lanceolate cell contracted.

Two specimens from Albania, from the late Sir S. E. Saunders's collection.

Allied to *M. femoralis* and *corallipes*, Eversm., in both which species the cell is subcontracted.

CHALCIDIDÆ.

CHALCIDINÆ.

4. TRICHOXENIA CINERARIA, *Walk.* (Pl. I. figs. 4, 5.)

Long. corp. 11 millim., exp. al. 18 millim.

Male. Black; antennæ very thick, with the second and third joints very short; scape red at the tip above; face clothed with silvery pubescence, shading into golden yellow above; thorax black, variolose; tegulæ black, a bright golden spot on each side at the base of the scutellum, and the sides of the metathorax fringed with golden hairs above; abdomen with the first segment black, variolose, its sides and extremity above, and the sides and upper surface of the remaining segments thickly clothed with bright golden hairs; abdomen black beneath; femora black, clothed with silvery hairs; tibiæ and tarsi with a reddish shade, and hind tibiæ clothed with yellow hairs; spines of the hind tarsi golden beneath; wings and general structure as in the female.

Hab. Australia (*Du Boulay*).

This beautiful insect, which strongly contrasts with the black female, has a striking general resemblance to some species of *Mutilla*; but it is worthy of note, first, that this resemblance is confined to the male, and, secondly, that the *Mutillæ* which it most resembles are not Australian species.

I am indebted to Signor P. Magretti for permitting me to describe the three following species, taken by him in the Soudan. All the other species in this paper are in the collection of the British Museum.

5. STOMATOCERAS MAGRETTII. (Pl. I. fig. 7.)

Long. corp. 9 millim.

Female. Black, variolose, with silvery hairs and down; antennæ —scape red, black at the tip; four following joints red, with short white pubescence, the rest black; third joint with a very distinct patch of white pubescence on the outside: tegulæ, stylus, and sides of first segment and under surface of abdomen shading into dull red; hind coxæ and last segment of abdomen before the stylus clothed with silvery hairs; legs black, shading into reddish, especially on the inner surface; middle femora somewhat thickened, all the tibiæ with a strong projecting spine beneath, and middle tibiæ armed with strong, stout, short bristles or spines, which are much more distinct upon the tarsi; hind femora armed with three large obtuse teeth; wings hyaline, with two brown bands.

Hab. Kassala (*Magretti*).

Allied to *Halticella liberator*, Walk., from Natal.

In describing the genus *Stomatoceras*, I stated that the metathorax was unarmed. In the two species here described it is armed with two strong teeth on each side; and I should expect to find this to be the case in well-preserved specimens of the previously described species of the genus.

6. STOMATOCERAS DIVERSICORNIS. (Pl. I. fig. 8.)

Long. corp. 4 millim.

Female. Closely allied to *S. Magrettii*, of which at first I regarded it as only a small variety. Black, variolose, silvery pubescence very slight; scape of antennæ and joints 2, 3, 4, and 11 wholly red; the joints longer and slenderer in proportion than in *S. Magrettii*; four front femora black; tibiæ and tarsi red, the former with a black streak on the inner side; hind femora black and shining, the middle tooth distinct, the others merely undulations; a small red spot at the base; hind tibiæ black, red at the tip, hind tarsi red; all the claws black; tegulæ black; wings hyaline, fore wings with two brown bands; abdomen reddish beneath, along the sheath of the stylus, which is comparatively short; metathorax with two strong teeth on each side.

Hab. Kassala (*Magretti*).

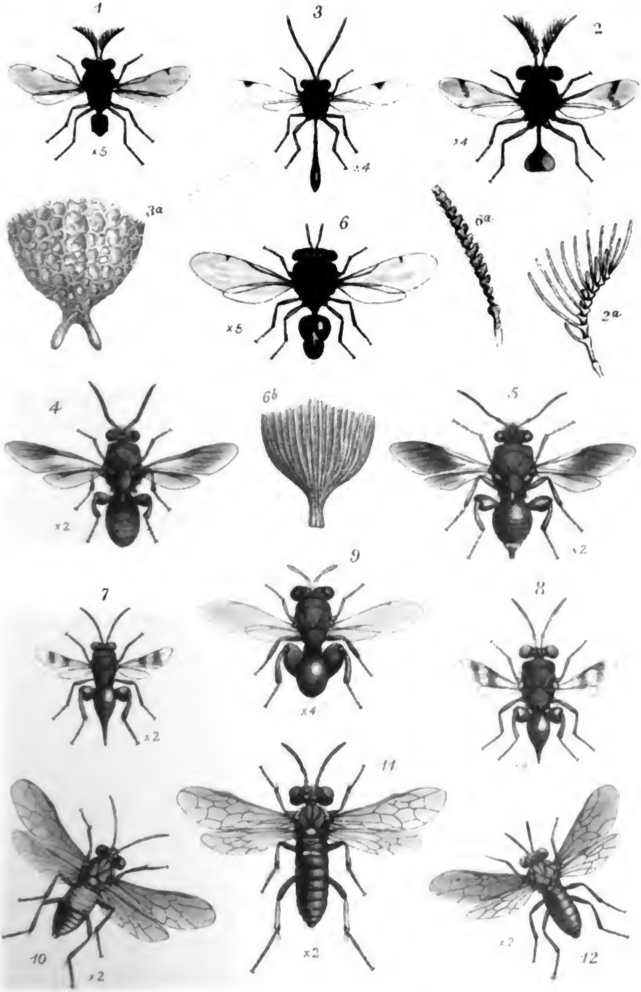
7. CHALCIS KASSALENSIS. (Pl. I. fig. 9.)

Long. corp. 5 millim.

Male. Black; head, thorax, and scutellum moderately closely variolose, each pit with a setigerous depression in the centre; the interspaces finely punctured; abdomen very finely reticulose; scutellum edged behind with silvery-white hairs; lower orbits, cheeks, pleuræ, terminal abdominal segments, and coxæ more or less clothed with silvery-white pubescence (antennæ wanting); tegulæ ivory-white; coxæ black; four front femora black, tipped with white; four front tibiæ white, with a short black line on the inner side; all the tarsi white, with the claws black; hind femora thickened, denticulated beneath, red, with a large white spot at the tip; hind tibiæ white, with a reddish-brown ring at the base; wings hyaline.

Hab. Kassala (*Magretti*).

Allied to *C. amenocles* and *C. restituta*, Walk.



SPECIES OF CHALCIDIDÆ AND TENTHREDINIDÆ.

Hammond, del. et lith.

Hanhart imp.

EUCHARISSINÆ.

SACCHARISSA, nov. gen.

Antennæ 18-jointed, scape rather long, second joint small, transverse, third and fourth simple, third longest, fifth to fifteenth short, with a series of long bristly fin-shaped projections on the upper surface, that on the fifth segment half the length of that on the sixth, the rest gradually decreasing until on joints 16–18 they almost disappear; scutellum with a long spear-shaped projection behind; head very narrow, transverse; ocelli arranged in a straight line; petiole short; abdomen short, ascending. (The abdomen is damaged in the type, and the figure may not therefore give the correct shape.)

Type, EUCHARIS CONTINGENS, Walk., from Borneo. (Pl. I. figs. 6, 6 *a*, 6 *b*.)

The species of *Eucharissa* are South-African insects, and their scutellum is unarmed.

EUCHARINÆ.

8. RHIPIPALLUS CAMERONI. (Pl. I. figs. 2, 2 *a*.)

Long. corp. 5 millim.

Male. Coppery, rugose; head and metathorax greener, antennæ brown, the rami less thickened than in *R. volusus*, Walk.; legs flavo-testaceous; hind coxæ globular, very dark green; petiole purplish cupreous, longitudinally striated; abdomen flavo-testaceous, brown on the back at the base; wings yellowish hyaline, with yellowish and unusually distinct nervures; a large smoky cloud below the cubitus.

Hab. Australia (?) or Celebes (?).

This very fine species much resembles *Chalcura deprivata*, Walk., in size and appearance.

DESCRIPTION OF PLATE I.

*Fig. 1. *Schizaspidia Murrayi*, Kirb., ♂.
2. *Rhipipallus Cameroni*, Kirb., ♂.
2 *a*. Ditto. Antenna.
3. *Stilbula cynipiformis*, Rossi, ♂.
3 *a*. Ditto. Scutellum.
4. *Trichoxenia cineraria*, Walk., ♂.
5. Ditto, ♀.
6. *Saccharissa contingens*, Walk., ♂.
Fig. 6 *a*. *S. contingens*. Antenna.
6 *b*. Ditto. Scutellum.
7. *Stomatoceras Magrettii*, Kirb., ♀.
8. *S. diversicornis*, Kirb., ♀.
9. *Chalcis Kassalæ*, Kirb., ♂.
10. *Hemidianeura Cameroni*, Kirb., ♀.
11. *Macrophya Saundersi*, Kirb., ♀.
12. *Selandria meridionalis*, Kirb., ♀.

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* *S. Murrayi*, Kirby, Ann. & Mag. Nat. Hist. (5) xiii. p. 403 (1884), from Tongatabu.

Occurrence of *Lumpenus lampetriformis* on the North Coast of Scotland; with Notes on its Habits, Food, and the Ground it frequents. By GEORGE SIM. (Communicated by Dr. FRANCIS DAY, F.L.S.)

[Read 17th June, 1886.]

LUMPENUS LAMPETRIFORMIS, the subject of the following remarks, is a northern form of the tribe Blenniidæ. It was described by Collett, a naturalist who accompanied the Norwegian North-Atlantic Expedition, 1876–78. According to this writer, *Lumpenus* appears to be a rather common fish in most localities along the Norwegian coast. As to its geographical distribution, I cannot do better than quote from a paper on the species under notice by Dr. F. Day. He says:—"Up to the present time (June 1884) this species has been recorded from the coast of Greenland and Iceland. It is common off Spitzbergen and on the shores of North-western Europe as far south as the Cattegat. In the north its range extends certainly as high as 80°." Collett says, "The southern limit of its range is probably Bohuslan, in Sweden, one or two individuals having been obtained off Gothenburg, 58° N." This latter writer's remarks on the species are of a general description; and nothing is said as to the nature of the ground *Lumpenus* frequents, the other living organisms that accompany it in its haunts, nor does he say a word as to the food of this interesting species. To these points the following notes more particularly refer.

The discovery of this species as British is of very recent date, the first example having been brought to light by Prof. McIntosh of St. Andrews in May 1884. This one he obtained fifteen miles off St. Abbs Head, while engaged in a series of observations on trawling, undertaken at the instance of the Scottish Fishery Board. Prof. McIntosh sent the specimen for examination to Dr. Day, who has described and given an excellent figure of it in the 'Proceedings' of the Zoological Society of London.

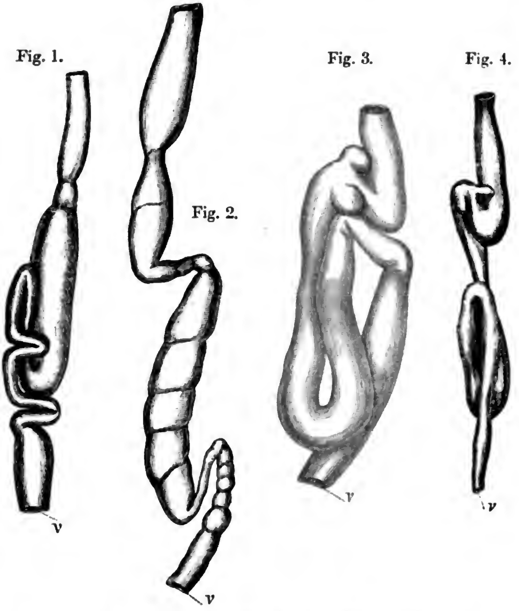
The second specimen found in Britain I obtained on an Aberdeen trawl-vessel on April 14th, 1885; and being quite unknown to me, and not having at that time seen Dr. Day's description of Prof. McIntosh's specimen, I made a sketch of the one now under notice and sent it to Dr. Day, who at once recognized it as *L. lampetriformis*, although differing very much in the form of the caudal fin from Prof. McIntosh's specimen, the difference being that McIntosh's specimen had the outer caudal rays elongated beyond the central ones for nearly half the length of the caudal fin; while in my specimen the central ray was longest, the others decreasing in length on each side of it, thus giving the tail a lanceolate form, or, as Collett says, an "acuminate form." Strangely enough, all my specimens have the same form of tail. On receipt of this information, the fish was forwarded to Cheltenham for examination by Dr. Day; and in due course I received a note from him stating that the specimen was a female *Lumpenus*, while that of Prof. McIntosh was an old male; and this he considered would explain the difference in the form of the tail.

The occurrence of this specimen Dr. Day recorded in 'Nature' for July 9th, 1885. Thus stood the matter until March 25th, 1886, on which date a second example came to my hand, and on March 31st eleven more; while from April 1st till May 31st fifty-seven specimens have made up my findings. This will indicate pretty clearly that the species is not so rare upon the coast of Britain as we were at first disposed to think.

In general appearance, *Lumpenus* approaches very nearly to that of our common Blennies, *Centronotus gunnellus* and *Zoarces viviparus*, to which it is closely allied; but on close examination it is seen to differ from them considerably, both in external colouring, fin arrangement, and internal organization. To give a minute description of the external appearance of *Lumpenus* is quite unnecessary, as this has been done by Dr. Day in the article already mentioned, as well as by Collett. My purpose, then, is merely to note the points where the three species differ and where they agree, in so far as I have been able to observe the same. Comparing *Lumpenus* with the Spotted Gunnel (*Centronotus gunnellus*), we find in both the spinous dorsal fin, the number of rays in *Centronotus* being 76 to 78, while in *Lumpenus* the number is 72 to 74; the latter number I have only once observed. In *Centronotus* the ventral fins have disappeared, and are represented by two short stout spines; in *Lumpenus*, however, these fins are comparatively well developed, each having one spinous ray and four soft ones. In the matter of dentition, *Centronotus* has a single row of conical teeth in both jaws, becoming shorter as they approach the angle of the mouth; sometimes there exist a few irregularly set teeth in the upper jaw in addition to the regular row; several strong teeth on the vomer; four patches, two on each side, of irregularly set upper pharyngeal teeth, and two long patches below, also set irregularly. On the other hand, *Lumpenus* is furnished in the upper jaw with numerous irregularly set teeth, the outer ones being conical, the others sharp-pointed, and all decreasing in length as they approach the angle of the mouth. The lower jaw is set with one, sometimes two rows of long incurved, rather sharp teeth, not of uniform length, and all becoming shorter laterally; none on the vomer or tongue. There are two irregularly set patches of upper pharyngeal teeth, each point of which is finely tinged with yellow; and four lower pharyngeals forming two sides of a triangle set confusedly, and without the yellow colour of the upper ones. In the number of vertebræ, *Centronotus* outnumbers *Lumpenus* by 3, the latter having 80 and the former 83.

But the greatest departure which *Centronotus* makes from *Lumpenus* is in the form of the stomach and intestines. As will be seen by the accompanying figures, the intestines of *Centronotus* in some cases show little change in the stomach from the intestines proper; that is, there is no very distinct line of demarcation between them; presenting more or less the form of a simple tube and are devoid of cæca. I have said in some cases. This will be best understood by referring to figs. 1 and 2, both of which represent the intestines of *Centronotus*, both drawn from specimens caught by myself and while the intestines lay *in situ*. This is a change in the internal arrangement of a species I have never before observed carried to such a length, although the individuals of no species have the intestines formed or laid exactly alike. The result of my investigation goes to show that fig. 1, or something much like it, is the most usual arrangement to be met with in *Centronotus gunnellus*. On the other hand, *Lumpenus* has what may be called a properly developed stomach, marked off from the intestines by its two cæcal appendages, and the intestinal track forms several convolutions in its course.

With reference to the cæca in *Lumpenus*, I find they differ much in length in different individuals, even although these individuals are of themselves the same size. In some examples these appendages are about ¼ inch long, while in others they are barely half that length. Is this difference in the stomach and intestines due to, or is this arrangement necessary to meet, the



Figs. 1 and 2. Stomach and intestines of *Centronotus gunnellus.*
Fig. 3. Stomach and intestines of *Zoarces viviparus.*
Fig. 4. Stomach and intestines of *Lumpenus lampetriformis.*

different conditions of food and habitat sustained by *Lumpenus* in comparison with its allies?

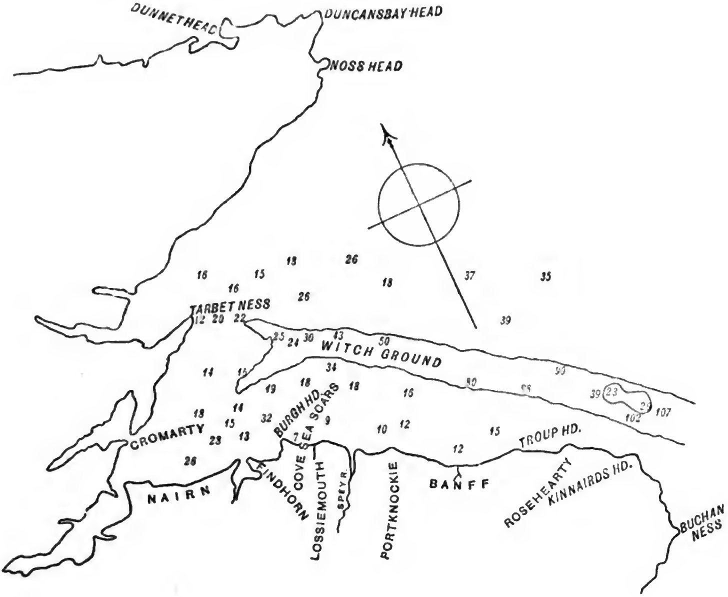
Turning to the Viviparous Blenny (*Zoarces viviparus*), as compared with *Lumpenus*, the difference in some points is greater than in the case of the latter and *Centronotus*; while in other particulars *Lumpenus* and *Zoarces* approach much more nearly to one another. In external form, *Lumpenus* is long and somewhat cylindrical, becoming compressed towards the caudal extremity, while in *Zoarces* the body is compressed along its whole length. Its dorsal fin has soft rays, 83 in number, after which are a few spinous rays; and the ventrals are well developed, having all the rays soft. In dentition *Zoarces* differs from *Lumpenus* in having a double row of teeth in both jaws, merging into one row, and becoming less in size as they approach the angle of the mouth. Six rows of upper pharyngeal teeth, viz. three on each side, the first a single row, the other two double. Lower pharyngeal teeth set in a double row which form a triangle; no teeth on the vomer or tongue. The number of its vertebræ is 116, whereas in *Lumpenus*, as already pointed out, these bones only number 80. In the case of the internal viscera, there is a great similarity in the two species under notice as compared with that of *Centronotus*. But the point wherein lies the greatest difference between these closely allied species is the fact of *Zoarces* bringing forth its young alive *.

Lumpenus is not viviparous. As to its time of spawning I cannot speak with certainty; at the end of April some of those I found had the roe pretty well advanced, much more so than was the melt of the males caught at the same time. Then, again, on May 20th I found one specimen measuring only 1¾ inch. Assuming that the species breeds only once a year, and taking into account the fact that those caught in April had spawn fully halfway advanced towards maturity, we may safely conclude that the spawning takes place in July or August, and that my 1¾-inch specimen was one of last year's young. On being boiled, the vertebræ of *Zoarces* become a fine deep-green colour, those of *Lumpenus* remain white.

It will thus be seen that although *Lumpenus* has something in its composition similar to both our common species; it is at the same time so widely different that no doubt need be entertained as to its being a distinct and well-marked species, nor any difficulty experienced in recognizing it from its congeners.

* On April 22, 1886, I had two specimens of this fish—one of them with its young, of which there were thirty, almost ready for expulsion, each measuring 2¼ inches; and in addition to these there were thirty-one more, evidently the young of the former year, which had not been given birth to; they were all firmly fixed together and in a hard wasted condition, yet capable of being separated individually. Why they had not been born at their proper time is a mystery difficult of solution.

The only locality where *Lumpenus* has yet been found on the north-east of Scotland is in a deep hollow in the Moray Firth, which runs almost parallel to the land, and extends from opposite the village of Roseharty on the Aberdeenshire coast to near Tarbetness in Rosshire, where it bifurcates, the other point running in the direction of the Cromarty Firth. Reference to the sketch-map above will show the "lie" of this ground. This hollow slopes gradually from the shore, but rises abruptly on the north-east or seaward side. It is from six to ten miles off shore, and 35 to 110 fathoms deep,



SKETCH-MAP OF MORAY FIRTH AND REGION AROUND, indicating the position of the "Witch Ground."

the greatest depth being at the Aberdeenshire end. This track is known to the trawl-fishers as the "Witch Ground." The reason for this name being given to it is because along a portion of the area, principally off "Covesea Scars," enormous numbers of *Pleuronectes cynoglossus*, the Pole or Craig Fluke, which these trawlers know as the Witch-Sole, are taken: hence the "Witch Ground." The bottom of this hollow is in some places composed of grey muddy sand, while in other parts it is principally covered with mossy matter. Concerning this latter material, considerable difficulty was experienced by me in coming to any definite conclusion regarding it. The question being, How came peat to be in such a locality? Was it matter washed by some river into this ground, or how came it to be there? It came first under my notice whilst examining the stomachs of the Witch-Sole. In many cases the stomach and intestines of this species contain portions of this peat which had been taken in along with the creatures upon which it feeds. However, during the storms which occurred in the month of January last immense sheets of peat were cast on our beach, which shows that at some long past age a forest of birch, hazel, and other trees had flourished, as also marshes filled with *Sphagnum*, *Polytrichum*, and other fresh-water-loving plants, where now swells the mighty waves of the North Sea. The remains of these sylvan beauties we now find composing the large masses of peat to which reference has been made. It is amongst this soft peaty ooze that our fossorial little friend *Lumpenus* loves to dwell, and amongst and on the surface of the same material where it finds its varied food, and where, in its turn, it becomes the food of its ever-watchful neighbours *Pleuronectes cynoglossus*.

The other living organisms that have come under my notice from the "Witch Ground" are, first, a few of the common Zoophyta, viz. *Tubularia indivisa*, *Sertularia abietina*, *Thuiaria thuia*, known in the locality as the bottle-brush weed; the "sea-pen" (*Pennatula phosphorea*), *Alcyonium digitatum*, locally known as "dead men's fingers," and the common *Flustra* also occur, but the last-named is perhaps only washed from the hard ground on the east of this great hollow.

Threading their way through the above-mentioned forms are those beautiful Ophiuroids *Amphiura Chiajii*, *A. filiformis*, *Ophiocnida brachiata*, *Ophioglypha albida*, *O. lacertosa*, and

Ophiothrix pentaphyllum. Here and there very sparingly distributed is also to be found that link which joins the present to the past—our elegant British Crinoid, *Antedon rosacea.*

From the depths of this vast aquarium we also sometimes obtain a specimen of that fine, but most repulsively odoured Starfish, *Stichaster roseus*, accompanied occasionally by *Palmipes membranaceus.*

Here also is that form which the late Prof. Forbes calls one of the rarest and most beautiful of our native Starfish, *Hippasteria plana*; beautiful it unquestionably is; but in this long valley it is by no means rare, dozens are sometimes brought up at one drag of the net. Accompanying it, but in very much fewer numbers, is its exquisitely coloured little brother, *Porania pulvillus.* And yet again, along this great expanse of mud, sand, and peat, live *Astropecten irregularis* and *Luidia Savignyi*, the latter a form more troublesome and tantalizing in its habits than any of our Starfish with which the lover of Nature may come in contact. Hundreds of this fine form are brought up both by trawl and line, but only to fall in pieces on coming to the surface, or, as Forbes says, "in a minute he proceeds to dissolve his corporation."

Of the Echinoidea which frequent this ground, we have *Echinocyamus pusillus*, *Spatangus purpureus*, *Brissopsis lyrifera*, and *Echinocardium cordatum*, while in each suitable resting-place are specimens of *Priapulus caudatus*, a favourite food of the "Witch-Sole." *Aphrodita aculeata* is also present in abundance.

The Crustacea to be met with along these grounds are numerous and highly interesting. Heading the list comes *Cancer pagurus*, *Lithodes maia*, *Nephrops norvegicus*, *Corystes cassivelaunus*, *Calocaris Macandreæ* (the latter is eaten in enormous numbers by the Witch-Sole), *Galathea squamifera*, *G. dispersa*, and *G. Andrewsi*, *Pagurus Bernhardus*, *P. Thompsoni*, and *P. Prideauxi* (always accompanied by its humbler friend *Adamsia palliata*), *Portunus holsatus*, *P. pusillus*, and *P. depurator*, *Crangon vulgaris*, *C. bispinosus*, and *C. trispinosus*, *Hippolyte spinus*, *Callianassa subterranea*. *Pandalus annulicornis*, various species of the genus *Diastylus*, accompanied by their kindred form *Eudora truncatula*, and several of the Mysidæ literally swarm. These are all the higher Stalk-eyed Crustacea; but in addition to the above list there is another stalk-eyed form, of which I have taken several specimens from the stomach of the Witch-Sole; it is not, so far as I am aware, described in any British work, and it therefore remains unnamed.

In Sessile-eyed Crustacea of the orders Amphipoda and Isopoda the ground is very rich. As to the identity of *Anonyx denticulata*, *Hypera galba*, and *Arcturus longicornis* there is no doubt; but many others are in my possession which are not yet identified. *Pycnogonum littorale* is abundant.

Turning to Molluscan life, the list is a fairly large one. First of all, on account of its numbers, delicate structure, and fine sculpturing, comes that lovely little form *Philine scabra*, followed by *Nucula nitida*, *Solen pellucidus*, *Tellina fabula*, *Scrobicularia prismatica*, *Psammobia Ferroensis*, *Donax anatinus*, *Mactra stultorum* and *M. solida*, *Pleurotoma turricula*, *Tornatella fasciata*, *Dentalium entale*, *Venus lincta*, and *Aporrhais pes-pelicani*; while *Pholas crispata* finds a congenial home in the easily perforated peat. Many other shells have been seen, but not living; so that in all likelihood they have been merely washed by the waves to the "Witch Ground" after the death of their occupants.

Food-fishes other than the Witch-Sole are scarce and of bad quality along this ground; and, according to the trawl-fishers, many of the Cod and Haddock caught there have some wound upon them, or are otherwise lean and out of condition. For this reason some of the fishermen give this hollow the name of the "Fish Hospital," because they think the sickly fish have come in so that they might heal their sores and recruit their strength.

Such, then, is an outline, necessarily very imperfect, of the living organisms which frequent the ground which *Lumpenus* haunts and in which it burrows. For the latter statement there is perhaps no absolute proof; but that it is fossorial I am strongly inclined to think, from the fact of its always being caught by the trawl ground-rope. In the narrow openings between the outer coils of this rope it is generally firmly jammed, invariably accompanied by masses of sand, mud, and peat, of which, as already stated, the bottom is composed.

It would seem that the ground-rope, in cutting through the uneven surface, comes upon *Lumpenus* in its retreat, and fixes the creature in its folds before there is any chance of escape. Were the fish a free-swimmer only, the chances are very slight for such a slender form to be caught at all.

The next question to which attention had to be directed was, upon what does *Lumpenus* feed? Although many of the fish obtained were so much injured as to be rendered useless as specimens, fortunately the stomach of each had escaped mutilation, and therefore the contents were at my disposal; another favourable circumstance was that each stomach was well filled. Microscopical examination of the contents of their stomachs reveals the fact that the food of *Lumpenus* is almost a purely crustacean one, confined in a very large measure to the Entomostraca and Copepoda; but in addition to these, I have found in several numerous immature specimens of the two genera *Diastylus* and *Edora*, minute bivalve mollusks, annelids, and several very small fish-scales, minute starfish of the genus *Amphiura*, a crustacean evidently parasitic (this I infer from the fact of its being furnished on each foot with a strong long circular claw or hook), very small forms of *Priapulus caudatus*, and a number of brown pear-shaped objects quite unknown to me; also sessile-eyed crustacea (Amphipoda).

As already stated, the Entomostraca and Copepoda largely predominate, the species in greatest number being what seems to me *Dactylopus tisboides* of Brady. Along with it is another form of the same genus, and very like *D. tisboides* in every way except that the last abdominal segment terminates in a long sharp cylindrical telson, at each side of which, and somewhat under it, are two short terminal segments from which issue several setæ of unequal length. Another creature presenting itself in some abundance is in general form somewhat like *Idotea parallela* of Bate and Westwood; but differs from that species, first, in being very small, and in having its body divided into thirteen segments instead of nine as in *Idotea*, and also in having the first pair of feet very powerful, terminating in equally strong didactyle hands. Its name remains unknown to me.

Then follow two species of the genus *Cythere* of Baird; they occur in about equal numbers; one seems to me to be *Cythere minna*; but if Baird's figure and description are correct, those I have cannot belong to that species. *C. minna*, according to Baird, is "obtusely rounded on the anterior extremity;" my specimens are equally acute at both ends. Can it be a species not described by the author just quoted? The second form answers to the figure and description of *Cythere pellucida* of Baird.

In naming these latter creatures specifically, I have done so with considerable hesitation, as it must be confessed my knowledge of these groups is much too limited to warrant my speaking with any great degree of certainty.

Thus ends my notes on *Lumpenus lampetriformis*; and I trust its habits and history have not been left shrouded altogether in the darkness in which I found them.

Since writing the foregoing I got, on June 5th, five more specimens of *Lumpenus*, one of them, a female, carrying spawn, which would have been deposited within a fortnight or three weeks at latest. This brings my supposition relative to the time of spawning to be pretty nearly correct, viz. the end of July or beginning of August.

The longest specimen mentioned by Collett was 412 millim.; my longest one was 12½ inches.

On the Anatomy of the Perignathic Girdle and of other Parts of the Test of *Discoidea cylindrica*, Lamarck, sp. By Prof. P. MARTIN DUNCAN, F.R.S., and W. PERCY SLADEN, F.G.S., Sec. L.S.

[Read 17th June, 1886.]

DISCOIDEA CYLINDRICA, the *Galerites cylindricus* of Lamarck, is one of the commonest of the Echinoidea from the Upper Cretaceous strata; and its shape and internal casts in flint are familiar to all geologists. Desor, Wright, and Cotteau have described the species; and the last-named palæontologist has enlarged the generic diagnosis of *Discoidea* in consequence of some morphological details which had been elaborated by himself and some previous observers, especially E. Forbes and Lovén.

Discoidea cylindrica has five basal plates in its apical system, and the fifth or the posterior one is not perforated for a genital duct. But the palæontologists just mentioned found a perforated fifth basal in species which they felt bound to classify in the genus *Discoidea*. Lovén, speculating on this association of imperforate and perforate basals in different species of the same genus, considered it an instance of evolution during time. Cotteau extended the generic diagnosis, and added to that of Desor the following:—"Apical system compact, subpentagonal, presenting in some species five genital plates which are perforated, and in some other species a complementary imperforate plate in the position of the odd generative plate" (Éch. du Dépt. de la Sarthe, 1869, Supp. p. 412). Desor had restricted his diagnosis to the structures with which he was acquainted; but his specimens do not appear to have been good ones, for he stated that the apical system is small and rarely distinct in its details; but he noticed that the odd genital plate is not perforated by the duct, and that the ocular plates are very small ('Synopsis,' p. 175).

The late Dr. Wright is at issue with all the other describers of the species about the extent of the madreporite; and his descriptions of the ambulacra and interradia of *Discoidea cylindrica*, upon which he placed a specific value, are doubtful. There are therefore many reasons why this familiar form should be studied, and especially as in one of the many beautiful specimens in the British Museum the perignathic girdle is exposed and can be understood. We propose, therefore, offering the results of our study of the most important details of the test in this and some other species of the genus, and we trust that some of the differences of opinion have now been settled, and that some fresh anatomical details have been utilized.

Apical System.—The specimens examined in reference to this and all the other anatomical structures are in the British Museum, the Museum of Practical Geology, Jermyn Street, and one is in our possession. The full-grown specimens show how small the apical system is in relation to the dimensions of the test, that there are five basals, none being complementary, and that whilst four of them (Nos. 1 to 4) are perforated by genital ducts, all of the five are penetrated by the madreporite. There are faint or decided grooves between the basals. In the largest specimens the distribution of the madreporite is well shown; and in No. 4663, Brit. Mus., the fifth basal is large and pentagonal, and is marked only by a few of the pores of the madreporite; and in a smaller specimen which is half-grown, belonging to us, the pores are absent in the fifth basal.

Dr. Wright (Monogr. Cret. Echin., Pal. Soc. Lond. 1874, vol. i. pt. vi. p. 207, pl. xlvi.) refers to the apical system. The type he examined has a perfect apical system, and each of the basals is perforated by the madreporite, and four basals are perforated by the genital ducts. But the author, by an unfortunate oversight, states that the madreporite is only seen in the right anterior basal. This is erroneous, and so is the figure given in his plate. The same specimen shows the very small size, comparatively, of the radial plates (oculars).

It is evident then that the adult forms of *Discoidea cylindrica* have all the five basals perforated for the madreporite, and all, except the fifth, perforated for the genital duct.

The Ambulacra.—Wright was the first to point out that the simple, straight condition of the pairs of pores was not universally found in the species, but that the pairs on the actinal area might fall into a biserial arrangement.

Now it appears to us that allowance must be made for the age and size of the tests in considering the particular distribution of the pairs of pores; for in the largest specimens the arrangement of the pairs differs from that seen in the immature forms, especially near the peristome. Again, there is a point which must be remembered, and it is that in full-grown specimens the ambulacra are flush with the test above the ambitus and raised above its level actinally. The poriferous zones are on the slant of the raised surface actinally; and it is on this slope that the greatest crowding of the pairs of pores happens. Above the ambitus the simple arrangement of the pairs in one row is invariable; and it is seen in small forms even near to the peristome. As a rule, the pairs are not crowded above the ambitus; and they may be larger there than actinally, where the crowding may be considerable.

The height of the ambulacral plates differs according to position and age. They are high near the peristome in young forms, and low close to the ambitus; and they are less unequal in adults. The horizontal sutures between the plates are often slightly furrowed.

The plates may be primaries, or compound with two or three constituents. The plates near the apical system and extending towards the ambitus are primaries. Taking the specimens in the British Museum, Nos. 38742, 723, and E 180, and also the half-grown specimen in our possession as examples, it is to be observed that near the radial plates there are low, broad primary plates, each having a pair of pores placed close to the interradial suture*. The pores are large and separated by a ridge; and they are very obliquely placed in reference to the transverse sutures of the ambulacral plates. The outer pore is aboral, and is very close to the edge of its plate and the interradium; and the inner pore is adoral, and either close above the line of suture or on it; and in the first instance a narrow linear prolongation of the pore may occasionally be seen passing down to the suture between the plate and the next in adoral succession (figs. 1 and 1 *a*). (B.M. 38742.)

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* The late Dr. Wright (*op. cit.* p. 207) seemed to separate the poriferous zones from the ambulacral plates; for he wrote, "The poriferous zones are

Fig. 1.

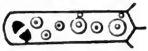
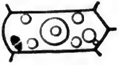


Fig. 1*a*.



The number of these primaries is considerable; and they almost reach the ambitus in specimens which are not adult. They are followed by, or alternate with, compound plates composed of a primary and a low, short demi-plate (fig. 2), or a demi-plate may be intercalated between two primaries, the three not forming a compound plate (fig. 2 *a*). (B.M. 723.) The demi-plate in this instance was a primary which has been crowded-out by the growth-pressure of the primary above and below; but in the other instance (fig. 2) the demi-plate has been so pressed upon that it has been fused, as it were, with the primary.

Fig. 2.

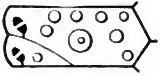
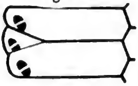
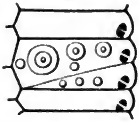


Fig. 2 *a*.



Both in the specimen marked 723 in the British Museum and in one in our possession the primaries are followed, at the ambitus or just above it, by taller compound plates, each of which consists of a large primary placed abactinally, and a low, broad, triangular demi-plate situated actinally. The two plates are united by very delicate sutures and form a geometrical compound plate (fig. 3). (See also B.M. 180.)

Fig. 3.



Sometimes, at the ambitus, there is a third plate in a compound plate; and the arrangement seen is very unusual in the Echinidæ. For:—(1) The pairs of pores are very slightly out of the straight vertical line. (2) The upper plate is a large primary which occupies the whole of

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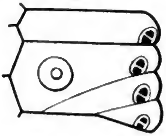
very narrow, and have one pair of small round holes opposite each ambulacral plate." The pores are of course in ambulacral plates. On the same page it is stated, "near the mouth-opening two rows [of pairs of pores] go to each plate." This is incorrect; for there is but one pair to a plate.

the compound plate at the median suture of the ambulacrum (fig. 4). (B.M. 180.) (3) There are two demi-plates; the upper one has its aboral suture passing actinally so as to reach the adoral suture of the compound plate at a little distance from the median suture; whilst the lower demi-plate has its aboral suture also sloping actinally and reaching the common adoral suture not far from the interradial edge.

Fig. 4.

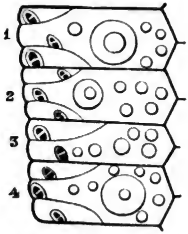


The position of these demi-plates is exactly opposite to that noticed in the compound plates of the Triplechinidæ*.

In nearly all the specimens the size of the pores diminishes actinally, but this is not invariable; and in all cases the pairs become closer, and alternate pairs are crowded out of the straight vertical line. There is no intercalation of pairs—that is, no new growths amongst the original pairs. Actinally, and on the slope of the raised ambulacra, which have already been noticed, the pairs of pores are crowded and biserial in their arrangement, and the pores are placed so obliquely that the aboral one is nearly vertical to the adoral. Although the crowding of the pairs is often excessive, still there is never more than a pair to a plate; and the plate, often very small, forms part of a compound plate. Solitary primary or demi-plates which do not enter into the composition of compound plates are not found below the ambitus. The compound plates there consist of a primary with one or two demi-plates.

The following is a description of four compound plates placed near the ambitus and actinally (fig. 5). (B.M. 38742.) Plate 1, the abactinal one of the series, consists of a large middle primary and a small aboral demi-plate and a larger adoral demi-plate. The aboral demi-plate is perforated by a pair of the outer set of pores of the biserial zone, and the primary by a pair of the inner set, whilst the adoral demi exhibits a pair of pores similar to those of the aboral demi-plate. But the primary occupies the whole of the median suture, and the demi-plates do not come in contact; for the adoral suture of the

Fig. 5.



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* Lovén, 'Etudes,' pl. xvii.

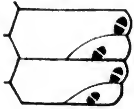
upper one curves aborally to reach the aboral suture of the compound plate, and the adoral demi-plate has its aboral suture curved so as to reach the adoral suture of the compound plate.

The next compound plate (2) is formed in the same manner as that just described; but the demi-plates are smaller, and are perforated by pairs of pores which belong to the inner set; on the other hand, the primary placed between the demi-plates has a pair of pores of the outer set, and this is the reverse of what occurs in the plate above. Plate 3 has only two components, and the abactinal plate is a low broad demi-plate perforated by a pair of pores of the outer set; the actinal plate is a low primary, and its pair of pores belongs to the inner set.

Plate 4 is formed like plate 2, but the demi-plates are larger; moreover, the pairs of pores of the upper demi-plate are of the inner set, like the pair seen in the demi-plate placed immediately abactinally in the compound plate above; but they are placed nearer the interradium than the pair above, and the result is to give a triple series of pairs of pores with the pair of the primary of plate 4. This triple appearance is rare in *Discoidea*. It will be observed that the composition of the four compound plates, omitting the biserial condition, is suggestive of that seen in the genus *Cœlopleurus*[*].

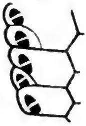
At some little distance from the peristome the alternation of outer and inner pairs of pores continues, and the compound plates are rarely formed of more than two plates. The primary of the compound plate is low and broad, and is placed abactinally, whilst the very small demi-plate is found at the actinal and outer part of the plate. When a tubercle is present, the primary becomes high. The primary has a pair of the outer series of pores, and the demi-plate a pair of inner series (fig. 6).

Fig. 6.



In half-grown specimens a decided change occurs in the pairs of pores at a little distance from the peristome, and they become larger, wider apart, and the arrangement is nearly in simple series (fig. 7). The pores of each pair are very oblique and almost vertical; and the greater number belong to primaries which are higher than those nearer the ambitus. A few are in demi-plates. In older specimens the simple series close to the peristome is much shorter, and indeed barely

Fig. 7.



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[*] Duncan and Sladen, Journ. Linn. Soc., Zool. vol. xix. 1885, pl. i.

exists, the pairs not being so large comparatively as in the younger forms, and with their arrangement biserial.

In both instances the expansion of a tubercle-bearing plate increases its height; and it is followed by small low primaries or by a demi-plate. The adult specimens conform very much to the drawing given by Lovén of the peristome of *Discoidea conica* ('Études,' pl. xiv. fig. 125).

The peristomial end of the poriferous zones is contracted, and a series of tubercles separates the pairs from the position of the interradial suture; so that there were spines in rows up the narrow space of the peristomial funnel-shaped tube. The first pairs of pores are not visible from without, for they are high up in the peristomial tube, and are placed in the processes of a structure which is termed the perignathic girdle (Journ. Linn. Soc., Zool. vol. xix. p. 179.)

In a specimen attributed to *Discoidea cylindrica* in the British Museum (No. E 180), which is half-grown, and has not become cylindrical in outline above the ambitus, but is simply hemispherical, the arrangement of the plates above the ambitus is somewhat exceptional. The pores are large and oblique, being in simple series and rather distant. The first four plates of a certain set are low and broad; then comes a tubercle-bearing primary with a considerable downward expansion towards the median line. It is followed by a low primary which is almost a demi-plate on account of the diminution of its vertical measurement near the median line. This loss of size has been due to the growth of the primary above, and the pressure has made both plates to combine within a geometrical outline to form a compound plate. The next plate is a decidedly very low primary, and it is succeeded by a primary with a downward expansion forming a compound plate with a low primary, which is almost a demi-plate. This compound plate is followed by a low primary. Just above the margin in this specimen, the growth-pressure has altered the shape of the plates in a very instructive manner. There is a triplet, and the first plate of it is a large downwardly expanded primary; the next is a low and broad demi-plate, for the pressure has blocked out part of a low primary near the median line, and a demi has resulted. The third plate is a small narrow and low demi-plate; and this was once a very low primary resembling those further up. Pressure made it assume the shape of a common small demi, and then the three plates were joined into a triple compound one. It appears that in some specimens the outer set of pairs of pores on the flank of the raised ambulacra are larger than the inner series; and when this is the case, the alternations of the pairs are very well seen.

The width of the ambulacra, compared with that of the interradia, is from one fourth to one third; and above the ambitus there are nine pairs of pores opposed to two interradial plates*.

The Interradial Plates.—These gradually diminish in size towards the peristome, and still more so as they pass up the funnel of the peristome to the perignathic girdle. At the girdle the odd interradium (No. 5) has a single plate; and although we are not quite satisfied on the point, it appears that there are single plates at the peristomial margin of the interradia Nos. 1 and 3. Double plates are seen at the margin of the peristome in interradia Nos. 2 and 4.

This is the arrangement of plates noticed in the funnel-shaped peristomes of *Echinoneus* and *Amblypygus* †. Lovén has figured a solitary plate in the peristome of *Discoidea conica* in interradium 5 ‡.

The Peristome.—The actinal aperture is very small in relation to the dimensions of the test; it leads up through a sort of funnel-shaped tube to the peristomial margin, which is therefore well within the test, and not flush with its actinal surface. The peristomial tube becomes narrower upwards, and its upper margin merges into a remarkable perignathic girdle. The opening of the peristome actinally is very nearly circular, and in no instance is it worthy of the term decagonal; there is the slightest departure only from a continuous curvature. But when the upper margin of the peristome is seen from below, the outline departs more from that of a circle, and ten slight curves are seen—five, broad and decided, are interradial, and five, narrower and less formed, are ambulacral. There are no notches actinally; but at the margin of the peristome and at the edge of the perignathic girdle there are faint groove-like notches between the interradia and the ambulacra.

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* In describing the ambulacra, the late Dr. Wright stated that about three of its plates correspond vertically to one interambulacral plate (*op. cit.* p. 206); but in the plate drawn by Bone, pl. xlvi. fig. 1 *d*, nine pairs of pores correspond to two interambulacral plates; and that is correct.

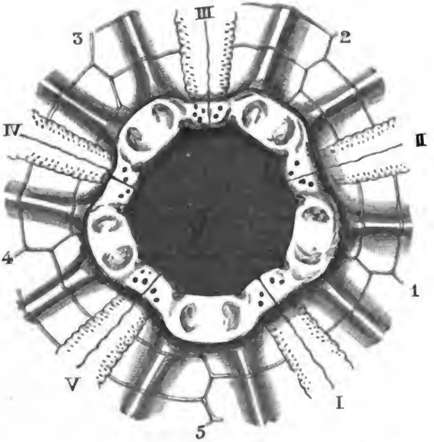
† Duncan and Sladen, Pal. Ind., ser. xiv., Tert. Echin. of Kachh, p. 17.

‡ Lovén, 'Études,' pl. xiv. fig. 125.

The curved edges of the inner extremity of the peristomial tube, as seen from below upwards, are not the terminations of the ambulacra and interradia; for when a section is made transversely through a test at the ambitus, and the chalk is cleared out from the actinal portion of the divided mass, plates are seen forming an internal oblique projection in the position of the perignathic girdle.

The projection is continuous around and above the peristomial tube, and is a perignathic girdle of a very remarkable and unique kind. The girdle is well seen in a specimen at the British Museum No. 40341 (fig. 8); and it will be observed that the so-called ribs, ten in number, which pass over the inner surface of the actinal interradial plates, commence at the outer edge of the interradial parts of the girdle. The girdle is rather low, and surrounds the peristomial opening in the form of a raised, oblique, broad, ridge-like ring. The upper surface of the girdle is free, and consists of flat or slightly irregular slanting surfaces, the slant being towards the peristome, ending all round and outwards in a continuous and wavy free edge. This edge has the parts which correspond with the ambulacra thin, less projecting than the other portions, and re-enteringly curved. The parts

Fig. 8.



of the edge of the girdle which correspond with the interradia are boldly curved outwards and are larger than the others.

The outer wavy free edge of the whole girdle overhangs the inner surface of the base of the test, and the ribs just mentioned arise from the underpart of the overhanging structure. The upper surface of the girdle is of course between the edge just alluded to and the peristome; and its slanting surface is not a simple plane one, for on each of the broader interradial portions there is a slight depression on either side of the centre and an elevation close to the ambulacral curves. This depression is probably the relic of a muscular origin, one on each side of the median line of a plate. No sutures occur in the interradial parts of the girdle; but it is not satisfactorily shown that there are not sutures between the ambulacral and interradial portions along the line of the slight groovings which are on either side of an ambulacrum high up in the peristome, and at the lower edge of the inner surface of the girdle—that is to say, in the usual position of sutures in relation with branchial grooves or cuts *. There is a distinct median and more or less vertical suture in every ambulacral part of the girdle, and there are pairs of pores on the sides of it (fig. 8).

In ambulacrum III., zone "*b*," there are two pairs of pores which are placed obliquely, as is the case with the single pairs of the other ambulacra, and the pairs of the other ambulacra are at different distances from the free edge of the ambulacral parts of the girdle; and these different positions are exactly those which occur in the particular plates around the peristomes of other regular Echinoidea according to Lovén. The lower part of the girdle is continuous with the ambulacral and interradial plates of the actinal part of the test around the peristome. The inner part of the girdle is the upper continuation of the peristomial tube.

The anatomy of the perignathic girdle in the Echinoidea was described by one of us in this Journal (Journ. Linn. Soc., Zool. vol. xix. p. 179, 1885); and that of *Discoidea cylindrica* was noticed as follows (p. 182):—"In *Discoidea* there is a continuous girdle without arches, although the homologues of the processes exist." Reference must be made to the above-mentioned communication in order to comprehend the terminology. It is evident that there are no arched parts in *Discoidea cylindrica*; but it is true that the ambulacral parts of the girdle are perforated by one or more pairs of tentacular pores; and therefore the parts thus penetrated are the homologues of the processes which in other Gnathostomes (omitting the Cidaridæ) form the sides to or processes of the arches ("auricles" of authors).

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* Duncan, Journ. Linn. Soc., Zool. 1885, pl. xxx. fig. 9, letter *s*.

The interradial portions of the girdle in *Discoidea cylindrica* are the homologues of the ridges of the other regular Echinoidea, including the Cidaridæ, and, as in the other forms, the ridges are composed of one or more interradial plates.

On comparing the girdles of *Cidaris* and *Discoidea*, it will be noticed that both have the ridges well developed, and clearly in consequence of the attachment of protractor muscles. In Cidaridæ the utility of the retractor muscles is diminished by the nature of the scaly structure around the peristomial opening; and in *Discoidea* the extremely high and narrow peristomial tube and the spines attached to tubercles within indicate that wide opening of the jaw-ends could not occur even as much as in *Cidaris*.

Neither in *Cidaris* nor in *Discoidea* are the "processes" of the ambulacral parts of the girdle developed so as to afford origin or attachment to muscles; and it is evident that the portions of the ambulacra in *Discoidea* which are perforated, and which are the homologues of the processes of the ambulacral arches of the Echinidæ, could not have given attachment to muscles because of the presence of the pores; moreover, the processes of Echinidæ are not the origins of muscles, but the arches are. The distinction in structure between the girdles of *Discoidea* and of the Echinidæ, such as the species of the genera *Echinus*, *Salmacis*, *Temnopleurus*, *Diadema*, *Cœlopleurus*, *Strongylocentrotus*, &c., is evident; for there are no arches and no upward prolongations or processes to form arches in *Discoidea*. The greatest affinity in structure is with the Cidaridæ; but the difference is important, inasmuch as the ambulacral parts of the girdle are wanting in Cidarids, and are high and block the ambulacral path in *Discoidea*.

No trace of pyramids or of any portions of a dental apparatus has ever been found in *Discoidea*; but it is impossible to reject the supposition that the genus was gnathostomous, for the presence of ridges marked with depressions in the girdle would seem to point to muscular attachments and to the inevitable presence of jaws. The position of the jaws was probably not so vertical as in the Cidaridæ, but slanting more or less; and it is probable that the teeth did not project, but moved as in the Clypeastroids. It is possible that the dental apparatus was slender, as it is in *Holectypus*.

The "Internal Ribs."—These ten ridge-like projections on the interradia within the test are low and narrow, but wider at their bases than at the free edge. They reach from the outer and under part of the perignathic girdle to the inner surface of the test just above the ambitus, and their height is about a millimetre near the girdle, and 3 millimetres at the opposite extremity.

There are two ribs to an interradial area, one on each side of the median line of suture of the interradium; and each one is placed along the middle of each row of interradial plates.

The ribs are not additional plates, but simply special upward growths of the middle portions of the upper surfaces of the interradial plates of the actinal part of the test. The sutures which are between consecutive interradial plates can be traced over the ribs. Finally, it must be noticed with regard to the growths of the inside of the test, that there is a low ridge along each median suture of the five ambulacra on the inside of the base of the test; it commences at the ambulacral part of the girdle, and gradually diminishes towards the ambitus of the test within *.

The Periproct.—This is small in relation to the size of the test, and is in a very slight concavity in the odd interradium, being nearer to the margin of the test than to the peristome. It is elongated in the direction of the antero-posterior axis of the test, and varies in shape from the elliptical with rather narrow ends to the ovoid with a considerable curvature posteriorly. It is bounded by four plates in one and five plates in the opposite zone; and the sixth plate from the peristomial margin, not including the first single plate, forms the inner boundary in one zone, and the seventh plate in the other zone.

The surface of the test, as has been remarked by nearly every observer, is remarkably punctate; and the multitudes of minute depressions have a corresponding number of small, close, sharp granules between them. The larger tubercles are in sunken scrobicules which are shallow; and there is decided crenulation and perforation.

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* Zittel, Handb. d. Pal. Bd. i. 1876–80, p. 514, fig. 373. The ten ribs are shown and part of the perignathic girdle.

The Fifth Basal Plate.—The specimens of *Discoidea cylindrica* in the British Museum show that the fifth basal is not a complementary plate, but a true basal which is not perforated for a genital duct, but which is penetrated by the madreporite. The position and dimensions of the plate are those of a normal basal in other forms; and it is not comparable with the so-called fifth plate described by Cotteau in one specimen of *Echinoconus albogalerus*, for that was a part of the left posterior basal. *Echinoconus* has no fifth basal.

The Evolution of the Fifth Genital Duct and the Perforation of the Fifth Basal Plate of Species of Discoidea.—Lovén has argued that during the lapse of time the generative organs of species of *Discoidea* became more fully developed after the anus moved out of the apex, and that the fifth plate reappeared and became perforated by a genital duct*. There is much to be advanced in favour of this remarkable generalization, and it is certainly the case that the oldest species had four basals perforated by genital ducts, whilst the youngest had five perforated basals. The oldest species do not, however, obtain a fifth genital duct, and its perforation during lapse of ages does not occur; for the oldest and youngest forms of *Discoidea cylindrica*, for instance, have only four perforated basals. *D. conica*, Desor, is a Gault and Albien species of Europe and Africa, and it follows Lovén's law, and has but four basals perforated by the duct, and the fifth is imperforate. *D. subuculus* ranges from the Warminster Upper Greensand into the Lower Chalk; and it has been described as having only four or sometimes five basals perforated; there are two specimens in the British Museum in which all the basals are perforated.

Discoidea minima, *D. Favrina*, *D. Jullieni*, and *D. Forgemolli* are European and North-African forms, and all have five basals perforated; and the age of the fossils is Cenomanien. *D. infera* and *D. Dixoni* are from the Upper Chalk, and all the five basals are perforated.

So far as the whole genus is concerned, the generalization of the appearance of the fifth basal perforation in the later ages of its lifetime is proved; but the appearance of a fifth perforated basal in time has not been proved to occur in the same species. The validity of this interesting observation by Lovén will have to be tested on other grounds; for it is a matter of considerable doubt in our minds whether all the species which have been admitted into the genus *Discoidea* can remain in it.

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* Lovén, On *Pourtalesia*, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Bd. xix. No. 7, 1883, p. 68.

D. subuculus differs much from *D. cylindrica* in the hollowed-out and tumid nature of the actinal part of the test, in the existence of low primary ambulacral plates only, and their great crowding without the formation of compound plates. Again, the madreporite is in the second basal only. Nevertheless, we have found ribs on the inner surface of the actinal part of the test, as in *D. cylindrica*; and probably the perignathic girdle will be found. As yet, we have only detected very indefinite traces of it.

On the Characters of the Genus *Lophopus*, with Description of a new Species from Australia. By STUART O. RIDLEY, M.A., F.L.S.

[Read 4th November, 1886.]

(PLATE II.)

PROBABLY in few groups of the Animal Kingdom have such unnatural characters been employed for the distinction of genera and species as in the Phylactolæmatous Polyzoa. Few systematic zoologists can, for example, have studied the relations of *Alcyonella* and *Plumatella* without feeling that the current reasons for separating these two divisions are far from satisfactory, consisting, as expressed by Prof. Allman in his well-known 'Monograph of the Freshwater Polyzoa' (Ray Society, 1856), chiefly in the manner of connection between the tubes composing the colony. "Except in the condition of the dermal system, the structure of *Plumatella* differs in no essential point from that of *Alcyonella*. This system, however, in the coalescence of the tubes into a common mass in *Alcyonella*, while they remain totally distinct in *Plumatella*, presents us with a difference which I believe to be of sufficient importance to justify us in placing the two forms in separate generic groups" (*l. c.* p. 92).

Dr. Jullien ("Monographie des Bryozoaires d'eau douce," Bull. Soc. Zool. France, x. p. 90, published in 1885) has given very forcible expression to this feeling of dissatisfaction, and has indeed introduced into the classification modifications of a very fundamental character, of which his union of the genus *Alcyonella* with *Plumatella*, and even the species of the former with species of the latter genus in a long list of synonyms, is not the most radical of the changes.

It is, however, my object on this occasion to draw attention to but one part of the existing systems which seems to require remodelling.

The diagnosis of *Lophopus*, as given by Allman (*l. c.* p. 83), runs:—"Cœnœcium sacciform, hyaline, with a disc which serves for attachment but not for locomotion; ectocyst gelatinoid; orifices scattered. Statoblasts elliptical, with an annulus, but without marginal spines."

Jullien (*l. c.* p. 139), besides characters derived from the general relations of the colony as a whole, inserts in his definition of the genus:—"*Statoblastes* elliptiques pourvus d'un anneau sur le pourtour; anneau terminé en pointe aux extrémités du grand diamètre."

The discovery, as detailed below, of a new species of the genus in Australia, involves the giving up of the last-named character as of generic importance, and *Lophopus* remains distinguished from *Cristatella* by the absence of spines from the statoblast and of a locomotor disk from the colony, and from *Pectinatella* chiefly by the former character.

LOPHOPUS LENDENFELDI, n. sp.

Zoarium forming chain-like or contort linear growths, the zoœcia being aggregated into small linear groups, which are connected with each other by stolon-like lobes. Zooids deeply divided from each other within the ectocyst, tubular, ending below in rounded, slightly constricted knobs terminated by a special thickening of the outermost layer of the endocyst. Ectocyst perfectly hyaline, about 1 millim. deep, forming low mammillæ, about ·02 millim. high, which contain the zoœcial orifices.

Tentacles about 50 in number, the longest longer than the endocyst-body. Epistome not observed. Ectocyst (in spirit) hyaline, colourless; endocyst-bodies pale yellow. Statoblast strictly elliptical in outline, annulus almost flat; body very convex.

Measurements.—Length of extended polypide (the portion within ectocyst-sheath) about 1 millim. Diameter of neck of zoœcium (endocyst) about ·02 millim. Length of lophophore, from root of arm to tip of furthest tentacle, about 1 millim. Maximum length of tentacles (in spirit specimens) about 1 millim.

Statoblast about ·85–·95 millim. long by ·7 millim. broad; annulus about ·22 wide at ends, about ·15 millim. at sides; cells of annulus about ·01 to ·05 millim. broad.

Habitat. Paramatta River, New South Wales.

The chief points distinguishing this species from *L. crystallinus* appear to be the absence of terminal angles to the statoblast, and the knobbed form of the inner end of the endocyst. The tentacles are also probably far longer than in *L. crystallinus.* No other species of the genus is known—that form assigned to it by Mr. Carter, from Bombay, evidently being rightly removed from *Lophopus* by Hyatt and Jullien. I have bestowed upon the species under notice the name of its indefatigable discoverer, Dr. von Lendenfeld, not only on account of his discovery, and of the very remarkable manner in which he has preserved the specimen, which shows almost all its characters as in life, but also in commemoration of his generosity in presenting it to the Natural History Museum, and in allowing me to describe a new form, systematically and geographically of such high interest.

The particular specimen from which this description is drawn up coats some thin fasciated vegetable stems for a length of 3¼ inches, but probably was much more extensive originally; the mass thus formed is about 7 millim. in greatest diameter. The statoblasts are described from a specimen found in a dead colony, obtained at the same spot, which exhibits the characters of the ectocyst sufficiently for identification. The conditions under which the colonies are growing (practically covering the entire circumference of the object in which they rest) almost preclude the possibility of such approaches to locomotion as have been sometimes attributed to *L. crystallinus*; at the same time their attachment to the base is very slight. The body of the statoblast is dark umber-brown, the annulus colourless.

Minute Structure.—Staining with borax carmine has enabled me, in the excellent state of preservation of the specimen, to demonstrate clearly that the outermost layer of the ectocyst consists of substellate nucleated cells; these are most usually roughly oblong in shape, with the branches chiefly at the poles, and measure about ·015–·02 by ·005 millim., with a small nucleus and punctiform nucleolus; but interspersed abundantly among them are some cells with a globular central mass about ·01 millim.

wide, mainly composed of a large nucleus, which contains a nucleolus, itself about ·002 millim. broad.

These cells are not described by Allman (*loc. cit.*) or in Hyatt's papers (Proc. Essex Institute, vols. iv. & vi.), nor have I seen them noticed in any other paper which I have met with. Their form would seem to assign a mesodermic origin to them, but hitherto no overlying tissue has been found, to represent the ectoderm.

Floating Apparatus of the Statoblast.—The cellular structure of the annulus of the statoblast in those forms in which it is developed resembles that of the gemmule of true *Spongillidæ*, as elucidated by the researches of Carter, Marshall, and Vejdowsky, so strongly that it only requires to be pointed out in order to be recognized.

Australasian Species of Freshwater Polyzoa.

The only Australasian species of Freshwater Polyzoa recorded by Jullien (*l. c.*), and by Hutton, in his 'Catalogue of the Marine Mollusca of New Zealand,' is *Plumatella Aplini* of Macgillivray. A form assigned to *Plumatella repens*, var. *a* of Allman, is, however, described by A. Hamilton from near Napier in New Zealand (Trans. New Zeal. Inst. xii. p. 302); and Mr. Whitelegge is stated to have exhibited the same species, *Plumatella repens*, and *Fredericella sultana*, from New South Wales, in Proc. Linn. Soc. N. S. Wales, viii. (1883) pp. 297, 416. The genus *Lophopus* does not appear to have been hitherto recorded from Australasia.

DESCRIPTION OF PLATE II.

Fig. 1. *Lophopus Lendenfeldi*, n. sp. Part of the colony, attached to plant-stem, showing a subspiral arrangement of the zoarium. Natural size.

2. Part of the zoarium, showing zooids in different states of contraction or expansion. *a*. Hyaline (? cuticular) layer observed at termination of body of polypides. *b*. Food-mass in alimentary canal. ×40 diam.

3. Portion of the ectocyst, to show structure as exhibited by staining with borax carmine. *a*. Stellate cells; *b*. Globose cells. ×600 diam.

4. A statoblast, showing: *a*, annulus; *b*, body; *c*, blastodermic cells*? ×60 diam.

N.B. These figures are somewhat schematized, except as regards essential details.

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* These bodies appear to consist mainly of refractive granules and of a large nucleus. Perhaps they represent an early stage in the division of the germ-cell.

Fig. 2

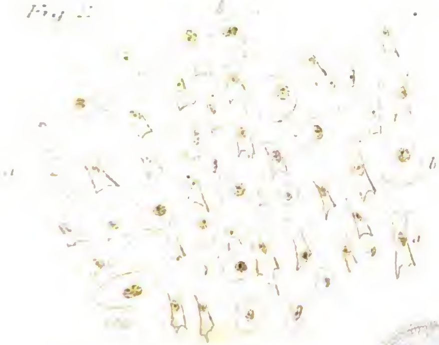

Fig. 1

Fig. [illegible]

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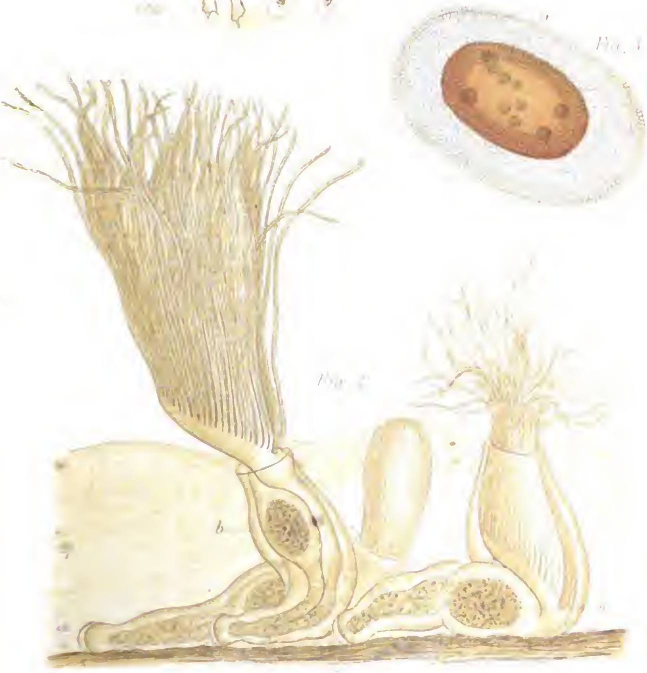

Experiments on the Sense of Smell in Dogs.

By GEORGE J. ROMANES, LL.D., F.R.S., F.L.S.

[Read 16th December, 1886.]

OF all the phenomena presented by the higher evolution of sense-organs in the Animal Kingdom, to my mind the most remarkable is the acuteness of olfactory perception which is exhibited by certain orders of Mammalia. All the other faculties of special sense are, so to speak, more evenly distributed throughout the vertebrated series; so that when we compare our own sense of sight, of hearing, or of taste, with those of vertebrated animals in general, we at once recognize that they are comparable. But such is not the case with the sense of smell; for in many of the Carnivora, Ruminants, &c., this sense has undergone so enormous a development as to be suggestive of differing from our own, not merely in degree, but in kind. Any one, for example, who is accustomed to deer-stalking must often have been freshly astonished at the precautions which it is needful to take in order to prevent the game from getting wind of the sportsman. Indeed, to a novice such precautions are apt to be regarded as implying a superstitious exaggeration of the possibilities of olfactory perception; and it is not until he has himself seen the deer scent him at some almost incredible distance that he lends himself without disguised contempt to the direction of the keeper. Yet among the Carnivora the sense of smell is even more extraordinary. Here, for instance, is an observation upon the subject which I published several years ago, and which I now quote because it led to the experiments which it is the object of this paper to detail:—

"I once tried an experiment with a terrier of my own which shows, better than any thing that I have ever read, the almost supernatural capabilities of smell in Dogs. On a Bank holiday, when the broad walk in Regent's Park was swarming with people of all kinds, walking in all directions, I took my terrier (which I knew had a splendid nose, and could track me for miles) along the walk, and, when his attention was diverted by a strange dog, I suddenly made a number of zigzags across the broad walk, then stood on a seat, and watched the terrier. Finding I had not continued in the direction I was going when he left me, he went to the place where he had last seen me, and there, picking up my scent, tracked my footsteps over all the zigzags I had made until he found me. Now in order to do this he had to distinguish my trail from at least a hundred others quite as fresh, and many thousands of others not so fresh, crossing it at all angles." *

The object of the experiments about to be described was that of ascertaining whether a dog, when thus distinguishing his master's trail, is guided by some distinctive smell attaching to his master's shoes, to any distinctive smell of his master's feet, or to both these differences combined.

I have a setter-bitch over which I have shot for eight years. Having a very good nose, she can track me over immense distances, and her devotion to me being very exclusive, she constituted an admirable subject for my experiments.

These consisted in allowing the bitch to be taken out of the kennel by some one to whom she was indifferent, who then led her to a prearranged spot from which the tracking was to begin. Of course this spot was always to leeward of the kennel, and the person who was to be tracked always walked so as to keep more or less to leeward of the starting-point. The district—park-lands surrounding a house—was an open one, presenting, however, numerous trees, shrubberies, walls, &c., behind which I could hide at a distance from the starting-point, and so observe the animal during the whole course of each experiment. Sundry other precautions, which I need not wait to mention, were taken in order to ensure that the bitch should have to depend on her sense of smell alone, and the following are the experiments which were tried:—

1.—I walked the grass-lands for about a mile in my ordinary shooting-boots. The instant she came to the starting-point, the bitch broke away at her full speed, and, faithfully following my track, overtook me in a few minutes.

2.—I set a man who was a stranger about the place to walk the park. Although repeatedly put upon his trail by my servant, the bitch showed no disposition to follow it.

3.—I had the bitch taken into the gun-room, where she saw me ready to start for shooting. I then left the gun-room and went to another part of the house, while my gamekeeper left the house by the back door, walked a certain distance to leeward in the direction of some partridge-ground, and then concealed him-

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* 'Mental Evolution in Animals,' pp. 92-3; where also see for additional remarks of a general kind on the sense of smell in different animals.

self. The bitch, who was now howling to follow me, was led to the back door by another servant. Quickly finding the trail of the gamekeeper, she tracked it for a few yards; but, finding that I had not been with him, she left his trail, and hunted about in all directions for mine, which, of course, was nowhere to be found.

4.—I collected all the men about the place, and directed them to walk close behind one another in Indian file, each man taking care to place his feet in the footprints of his predecessor. In this procession, numbering twelve in all, I took the lead, while the gamekeeper brought up the rear. When we had walked two hundred yards, I turned to the right, followed by five of the men; and at the point where I had turned to the right, the seventh man turned to the left, followed by all the remainder. The two parties thus formed, after having walked in opposite directions for a considerable distance, concealed themselves, and the bitch was put upon the common track of the whole party before the point of divergence. Following this common track with rapidity, she at first overshot the point of divergence; but, quickly recovering it, without any hesitation chose the track which turned to the right. Yet in this case my footprints in the common track were overlaid by eleven others, and in the track to the right by five others. Moreover, as it was the gamekeeper who brought up the rear, and as in the absence of my trail she would always follow his, the fact of his scent being, so to speak, uppermost in the series, was shown in no way to disconcert the animal when following another familiar scent lowermost in the series.

5.—I requested the stranger before-mentioned to wear my shooting-boots, and in them to walk the park to leeward of the kennel. When the bitch was led to this trail she followed it with the eagerness wherewith she always followed mine.

6.—I wore this stranger's boots, and walked the park as he had done. On being taken to this trail, the bitch could not be induced to follow it.

7.—The stranger walked the park in bare feet; the bitch would not follow the trail.

8.—I walked the park in bare feet: the bitch followed my trail; but in quite a different manner from that which she displayed when following the trail of my shooting-boots. She was so much less eager, and therefore so much less rapid, that her manner was suggestive of great uncertainty whether or not she was on my track.

9.—I walked the park in new shooting-boots, which had never been worn by any one. The bitch wholly refused to take this trail.

10.—I walked the park in my old shooting-boots, but having one layer of brown paper glued to their soles and sides. The bitch was led along my track, but paid no attention to it till she came to a place where, as I had previously observed, a small portion of the brown paper first became worn away at one of my heels. Here she immediately recognized my trail, and speedily followed it up, although the surface of shoe-leather which touched the ground was not more than a few square millimetres.

11.—I walked in my stocking-soles, trying first with new cotton socks. The bitch lazily followed the trail a short distance and then gave it up. I next tried woollen socks which I had worn all day, but the result was the same, and therefore quite different from that yielded by my shooting-boots, while more resembling that which was yielded by my bare feet.

12.—I began to walk in my ordinary shooting-boots, and when I had gone fifty yards, I kicked them off and carried them with me, while I continued to walk another three hundred yards in my stocking-soles; then I took off my stockings, and walked another three hundred yards on my bare feet. On being taken to the beginning of this trail, or where I had started in my shooting-boots, the bitch as usual set off upon it at full speed, nor did she abate this speed throughout the whole distance. In other words, having been once started upon the familiar scent of my shooting-boots, she seemed to entertain no doubt that the scent of the stocking-soles and of the bare feet belonged to me; although she did not clearly recognize them as belonging to me when they were not continuations of a track made by my shooting-boots (10 and 11).

13.—I requested a gentleman who was calling at the house, and whom the bitch had never before seen, to accompany me in a conveyance along one of the carriage-drives. At a distance of several hundred yards from the house, I alighted in my shooting-boots, walked fifty yards beside the carriage, again entered it while my friend alighted and walked two hundred yards still further along the drive. The bitch ran the whole 250 yards at her full speed, without making any pause at the place where the scent changed. This experiment was subsequently repeated with other strangers, and with the same result.

14.—I walked in my ordinary shooting-boots, having previously soaked them in oil of aniseed. Although the odour of the aniseed was so strong that an hour afterwards the path which I had followed was correctly traced by a friend, this odour did not appear to disconcert the bitch in following my trail, for she ran me down as quickly as usual. It was noticed, however, by the friend who took her to the trail that she did not set off upon it as instantaneously as usual. She began by examining the first three or four footsteps with care, and only then started off at full speed.

15.—Lastly, I tried some experiments on the power which this bitch might display of recognizing my individual odour as emanating from my whole person. In a large potato-field behind the house, a number of labourers had been engaged for eight or ten hours in digging up and carrying away potatoes all the way along half a dozen adjacent "drills." Consequently, there was here a strip of bared land in the field about twenty yards wide, and a quarter of a mile long, which had been thoroughly well trampled over by many strange feet. Down this strip of land I walked in a zigzag course from end to end. On reaching the bottom I turned out of the field, and again walked up a part of the way towards the house, but on the other side of a stone wall which bounded the field. This stone wall was breast high, and was situated nearly a hundred yards to windward of my previous course through the potatoes. The bitch, on being led out of the house, was put upon my trail at the top of the field, and at high speed picked out my trail among all the others, following roughly the various zigzags which I had taken. But the moment she gained the "wind's-eye" of the place where I was standing behind the wall, she turned abruptly at a right angle, threw up her head, and came as straight as an arrow to the spot where I was watching her. Yet while watching her I had allowed only my eyes to come above the wall, so that she proved herself able to distinguish instantly the odour of the top of my head (without hat) at a distance of two hundred yards, although at the time she was surrounded by a number of over-heated labourers.

16.—On another day, when it was perfectly calm, I tried the experiment of standing in a deep dry ditch, with only the top of my uncovered head above the level of the surrounding fields. When she was led within two hundred yards of the place, she instantly perceived my odour, and ran in a straight line to where I had then ducked my head, so that she should receive no assistance from her sense of sight. This experiment shows that, in the absence of wind, the odour of my head (and no doubt, in a lesser degree, that of my body) had diffused itself through the air in all directions, and in an amount sufficient to enable the setter to recognize it as my odour at a distance of two hundred yards.

From the above experiments I conclude that this bitch distinguishes my trail from that of all others by the peculiar smell of my boots (1 to 6), and not by the peculiar smell of my feet (8 to 11). No doubt the smell which she recognizes as belonging distinctively to my trail is communicated to the boots by the exudations from my feet; but these exudations require to be combined with shoe-leather before they are recognized by her. Probably, however, if I had always been accustomed to shoot without boots or stockings, she would have learnt to associate with me a trail made by my bare feet. The experiments further show that although a few square millimetres of the surface of one boot is amply sufficient to make a trail which the animal can recognize as mine, the scent is not able to penetrate a single layer of brown paper (10). Furthermore, it would appear that in following a trail this bitch is ready at any moment to be guided by inference as well as perception, and that the act of inference is instantaneous (12 and 13 as compared with 2, 8, and 11). Lastly, the experiments show that not only the feet (as these affect the boots), but likewise the whole body of a man exhales a peculiar or individual odour, which a dog can recognize as that of his master amid a crowd of other persons (15); that the individual quality of this odour can be recognized at great distances to windward (15), or, in calm weather, at great distances in any direction (16); and that it does not admit of being overcome by the strong smell of aniseed (14), or by that of many other footprints (4).

On the Loch-Leven Trout (*Salmo levenensis*).

By Francis Day, C.I.E., F.L.S.

[Read 2nd December, 1886.]

Salmo levenensis, *Walker*.

Salmo levenensis, *Walker, Wernerian Memoirs*, i. p. 541 (1808), *apud Neill* ; *Walker, Posthumous Essays on Natural History* (1812) ; *Yarrell, Brit. Fishes*, (ed. 2) ii. p. 117, (ed. 3) i. p. 257 ; *Günther, Catal. of Fishes*, vi. p. 101 ; *Couch, Fishes Brit. Isles*, iv. p. 243, pl. ccxx. ; *Houghton, Brit. Freshwater Fishes*, p. 123, c. fig. ; *Day, British and Irish Fishes*, ii. p. 92, pl. cxvi. figs. 2 & 2 *a*.

Salmo taurinus, or Loch-Leven Bull-Trout, *Walker, Essays, l. c.* (large examples).

Loch-Leven Trout, *Richardson, Fauna Bor.-Americana*, 1836, p. 143 ; *Knox, Proceedings Linnean Society*, vol. ii. p. 354, Dec. 1854.

Salmo cæcifer, *Parnell, Fishes of the Firth of Forth*, p. 306, pl. xxx., *and Wern. Mem.* vii. p. 146, pl. xxx.

Among the general public, anglers, and fishermen it has, from almost time immemorial, been a subject of argument as to whether the Loch-Leven trout should be considered a species distinct from the burn-trout (*Salmo fario*) ; and also, supposing it to be a distinct species, whether it may not be the descendant of a marine form which, having ascended the river Leven and obtained access into the loch from the sea, has been unable to return there. Scientific men have joined in this discussion and given or refused specific rank to the Loch-Leven trout; in the meantime, the form in question has been selected as the stock-fish for the justly celebrated Howietoun fish-farm of Sir James Maitland, which is within 25 miles of Loch Leven and at about the same elevation above the sea, and here facilities have existed for studying the race more closely, perhaps, than any other of our British trout.

In Sir Robert Sibbald's history of Kinross-shire, 1710, we read:—"Loch Leven abounds with fine fish, such as the salmonds*, taken in the summer . . . . The Grey-trout or Bill-trout, some of them as big as a salmond; greyish skinned and red fished, a foot long, taken all the year over. Cendue or Camdue in Irish, Blackhead, having a black spot on the top of its head, is fat, big as a Dunbar herring, red fished, much esteemed."

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* The term salmond was used so vaguely by some authors as applicable to both the salmon and sea-trout, that the simple name being given is hardly sufficient evidence of the presence of *Salmo salar*. Thus Sir R. Sibbald, in his 'Scotia Illustrata,' 1684, divided salmon from salmoneta, and referred to the latter as follows:—"Salmoneta, qui nostratibus the *Salmon-trout*" (p. 25). He also observed, "The Grey trout, or Bill-trout, some of them as large as a salmond"; but, as I shall show, this grey stage is not the livery of old specimens, and none have been recorded over 10 lb. in weight, it would therefore seem he referred to sea-trout; again, silvery trout in Scotch lochs are often classed as sea-trout.

Pennant, in 1769, went to Loch Leven, and observed:—"The fish of this lake are pike, small perch, fine eels, and most excellent trouts, the best and the reddest I ever saw; the largest about 6 lb. in weight" (Journ. 4th ed. p. 69). In his 'British Zoology,' 1776, he did not refer to any distinct species existing in Loch Leven; but after remarking on the large trouts of Lough Neagh in Ireland, locally termed Buddaghs, he continued, "Trouts (probably of the same species) are also taken in Hulse-water, a lake in Cumberland, of a much superior size to those of Lough Neagh. These are supposed to be the same with the trout of the lake of Geneva, a fish I have eaten more than once, and think but a very indifferent one" (iv. p. 299).

The Reverend A. Smith, 'Statistical Account of Kinross,' 1793, remarked that "In Loch Leven are all the different species of hill, burn, and muir trout that are to be met with in Scotland, evidently appearing from the diversity of manner in which they are spotted; yet all three different kinds, after being two years in the loch and arriving at ¾ lb. or 1 lb. in weight, are red in the flesh, as all the trout of every kind in the loch are, except, perhaps, those newly brought down by the floods, or such as are sickly. The Silver-grey trout, with about four or five spots on the middle of each side, is apparently the original native of the loch, and in many respects the finest fish of the whole. The fry of all kinds are white in the flesh till they come to the size of a herring, about the beginning of the third year. . . . . Those called bull-trout are believed to be the old ones. In spring, 1791, a large one was caught that weighed 10 lb."

Dr. Walker, in his posthumous 'Essays on Natural History and Rural Economy,' 1812, observed of the trout in Loch Leven:—"The first most frequent is called at the place *Grey Trout*, and is a fish not distinctly described by naturalists; it is found usually from 1 lb. to 2 lb. in weight, at times considerably larger. This is supposed to be *Salmo levenensis*, N. The second, called by the inhabitants Bull-trout, *Salmo taurinus*, N., supposed to be a distinct species; but there is reason to suppose this is the male of the above. These two are generally known in Edinburgh as

Loch-Leven trout. The third is called at Kinross the *Camday*, is 8 in. to 10 in. long, and reckoned a distinct species; but is only the grey trout at an early age." He likewise referred to three more species as the Burn trout, the Highland or Muir trout, and another form of bull trout, which he does not appear to have seen, found in the deep parts of the lake, attaining to 7 lb. or 8 lb. in weight, and with yellow flesh.

Graham, 'General Review of the Agriculture of Kinross and Clackmannan,' published about the commencement of the present century, after giving an account of the fish found in Loch Leven, remarked, "Flounders are also found in Loch Leven," which demonstrated that at this period sea-fishes were able to obtain access up the river Leven into the lake.

In the year 1874, Mr. R. Burns Begg, the ex-president of the Kinross Fishing Club, compiled an interesting account of the Loch-Leven trout, and of the locality which it inhabited. The Loch-Leven lake, prior to 1830, covered a superficial area of 4312 acres; it is situated 360 feet above the sea-level, and receives the waters of the Garny and of the north and south Queich; while the mean flow from it throughout the year amounts to 4000 cubic feet a minute, which goes into the river Leven, and this river, after a course of 14 miles, falls into the Firth of Forth. In December, 1830, the loch was diminished to three fourths of its original dimensions, or to 3543 acres, by an extensive drainage operation, which permanently reduced its natural level to the extent of four and a half feet, and means were likewise devised by which, when desired, another four and a half feet can be drawn off. Fleming made a careful inspection of the loch during the years 1834 and 1835, in order to ascertain what effect the drainage had had upon its fisheries, and he concluded that they were permanently diminished one-third in their value, the sluices acting injuriously to young fish by reason of the strong current at the outflow; and that the margin of the lake had undergone a change unfavourable to its piscine inhabitants, owing to the peculiar barrenness of the shore rendering the new margin ill suited for supplying them with food. In the lake itself, however, the water-snails were found not to have been destroyed.

Many have supposed that the superior flavour of Loch-Leven trout is a consequence of the quality and abundance of the food which they could obtain there.

In the 'New Statistical Account of Scotland,' mention is made of a trout taken April 27th, 1841, that weighed 10 lb., being 27 inches long and 17 inches in girth. We are likewise told of the fish in this lake, that their superiority in quality is not confined solely to the Loch-Leven trout proper, but is to be observed in the common trout, and even in the pike, perch, and eels; also that the trout of Loch Leven do not continue to exhibit the same distinctive superiority when they are removed to other waters. In new quarters, however favourable such may appear to be, they are said to invariably deteriorate and lose much of their quality.

The peculiarly excellent food in the water at Loch Leven has been supposed to consist of a small reddish-coloured mollusk, believed to be restricted to the shallow shingly beds lying near to the shores (the form here alluded to would seem to be a *Limnæa*), and the sessile-eyed crustacean, "screw" or "water-shrimp," *Gammarus*. Mr. Wilson concluded that it was owing to the abundant and perpetual breeding of these and other living creatures that the trout in question owed their superiority. A fisherman, however, who had the management of the curing of the trout, and had observed the food taken from their stomachs, remarked that he had never observed any small shells, but mostly worms, minnows, perch, and young trout. Furthermore, evidence was adduced by fish-dealers and others who had been regularly supplied with trout, both before and since the drainage, who distinctly stated that they could observe no deterioration whatever in the fish. Parnell, however, held a different view; and there cannot be a doubt that the stock of fish largely diminished from some cause.

Whether this form is or is not the *Salmo cumberland* of Lacépède, in his 'Histoire Naturelle des Poissons,' vol. v. p. 696, cannot now be determined from the meagre description which has been handed down to us; but that author described it as having a small head, white flesh, and being externally of a grey colour. A correspondent of Loudon's 'Magazine of Natural History,' 1832, vol. v. p. 317, remarked upon a form of trout which was found in Ulswater and Windermere, termed by the residents a "grey trout" and having the habits of a char, which he likened to Lacépède's fish, and asserted was captured up to 20 lb. weight. Parnell in 1838, *l. c.*, appears to be the first who scientifically investigated this form of trout, and from his remarks we learn that he considered "the differences that exist between *S. cæcifer* (as he termed this form) and *S. fario* are very striking. The pectorals of *S. cæcifer*, when expanded, are pointed; in *S. fario* they are rounded. The caudal fin in *S. cæcifer* is lunated at the end; in *S. fario* it is sinuous or even. *S. cæcifer* has never any red spots; *S. fario* is scarcely ever without them. The caudal rays are much longer in *S. cæcifer* than in *S. fario*, in fish of equal length. In *S. cæcifer* the tail-fin is pointed at the upper and lower extremities; in *S. fario* they are rounded. The flesh of *S. cæcifer* is of a deep red, that of *S. fario* is pinkish or often white. The cæcal appendages in *S. cæcifer* are from 60 to 80 in number; in *S. fario* I have never found them to exceed 46." He also observed that this fish does not appear to be peculiar to Loch Leven, as he had seen specimens that had been taken in some of the lakes of the county of Sutherland.

Sir John Richardson, in the 'Fauna Boreali-Americana,' *l. c.*, remarked that in "external form, the proportional size of various parts of the head and gill-covers, the size of the scales and the dentition, agrees with *S. lemanus* . . . . . Three individuals of the Loch-Leven trout that were dissected had each 73 pyloric cæca, and in one of them 59 vertebræ were counted." Yarrell added nothing to the previous descriptions. Knox, 'Lone Glens of Scotland,' 1854, observed of this trout of Loch Leven, that it "is a beautiful silvery dark-spotted trout, imagined by some to be peculiar to the lake. This, however, is not likely, since trout quite resembling those of Leven are found in many northern lakes" (p. 36). He concluded, after citing some of the opinions of others, that he was "disposed to think that two species of trout inhabit Loch Leven, independent of the common river trout; namely, the trout which lives on entomostracæ, and comes into season in December, January, and February; and the trout, which, feeding on the buccinum, and on flies, worms, and all the common food of the common river trout, comes into season later in the spring" (p. 37). In the 'Proceedings of the Linnean Society' (Dec. 19th, 1854), Dr. Knox remarked that at first he thought this a specific form, "although anatomical investigation has not hitherto confirmed it."

Dr. Günther, *l. c.*, gave a fuller description than the previous authors whom I have quoted. He observed of this fish that it has the "body much less stout than in *S. fario* . . . . In the male sex a mandibular hook has never been observed. Maxillary much longer than the snout, but much narrower and more feeble than in *S. fario* (see figures, p. 6); in specimens 13 inches long it extends to below the hinder margin of the orbit, and at no age does it reach much beyond it . . . . The teeth of the body of the vomer form a single series, and are persistent throughout life. Fins well developed, not rounded." He found from 49 to 90 cæcal appendages. At page 6, *l. c.*, are figured two maxillary bones, stated to be from *S. fario* and *S. levenensis*[*], but the drawings not being completed at their proximal extremities render it almost impossible to understand what they are intended to represent. The supplementary bone would seem to be where the most difference exists. The same author likewise remarked (p. 7) on the question of species in Salmonidæ, and gave his reasons for admitting certain forms to that rank, stating that "whenever the zoologist observes two forms distinguished by peculiarities of organization such as cannot be conceived to be the effects of an internal or external cause, disappearing with the disappearance of that cause, and which forms have been propagated and are being propagated *uniformly* through all the generations within the limits of our observation, and are yet most probably to be propagated during the existence of mankind, he is obliged to describe these two forms as distinct, and they will commonly be called species." Dr. Günther has also stated, at a meeting of the Zoological Society, that the late Sir J. Richardson had informed him that he believed the true Loch-Leven trout had disappeared from that lake.

In giving a decision on the well-known "Orange-fin" case, in 1872, the Sheriff Substitute found that "in reference to the outward silvery appearance of the fish in question, both Dr. Günther and Professor Young state that the silvery coat with which these fishes is clothed is to be regarded as a distinctive mark of their being migratory fish of the salmon kind. The assumption of the silvery coat . . . . in the case of river fish, is to be held an almost infallible test of a migratory and sea-going habit. Nor is this inconsistent with the well-known fact, that in the case of certain fish which inhabit lochs having now no communication with the sea, a similar silvery appearance is to be seen. In the case of the Loch-Leven trout, which affords the most notable example of the phenomenon referred to, it must, however, be kept in view, as having an important bearing on the character of this fish, that the loch which it inhabits had, most probably, at one time a communication with the sea, and that the fish themselves possess in a most remarkable degree the features of the salmon and the sea-trout . . . . The fact of one of these trout having, in the course of the present trial, been regarded by Professor Young as a sea-trout, after examination, is a very strong testimony to the difference between the characteristic features of the Loch-Leven trout and those of all the non-migratory river-fish" (pp. 166, 167).

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[*] The teeth in the maxilla of *S. levenensis*, in Dr. Günther's figure, are shown as directed forwards and inwards; the base of each tooth appears as if resting on the skin with its point turned towards the maxillary bone!

In the year 1873 Sir James Maitland commenced fish-culture at Howietoun, and selected as the form of trout which he considered would prove best adapted for this purpose the true Loch-Leven breed, the eggs of which he obtained at the lake, and from which his present stock originated *. For some years he has assisted me, and allowed every facility for examining the fish in his establishment, while I have given very particular attention to the following question, *Is the Loch-Leven trout a distinct species or merely a local race?*

The first inquiry will therefore be, On what grounds has the Loch-Leven trout been regarded as a distinct species? Can any persistent differences from other trout be shown in its external form, its internal organization, its tints, or the colour or taste of its flesh?

As to external form, the Loch-Leven trout has been said to be much less stout, its head shorter, its fins more pointed, while the rays in its caudal fin are longer than those in the burn-trout; the posterior extremity of this fin is also said to be lunated and pointed at both its upper and lower angles, and its pectoral fin is likewise pointed. Also that the male has no hook on the lower jaw; that its maxillary bone is more feeble than in any other form of trout, and that it never extends posteriorly beyond the hind margin of the orbit.

As to its body being less stout than that seen in burn-trout, this is certainly sometimes the case, but such a character is not persistent. In the form of the body there is no difference perceptible in those fish reared in Gloucestershire, as I shall presently show, or at Mr. Andrews's establishment at Guildford, from eggs obtained from Howietoun, and young of brook-trout raised from local brook-trout eggs. As this is the case in fish reared from Loch-Leven eggs it is evident that their form ultimately depends upon local circumstances or conditions; for if they are removed to another locality where the conditions are different, the brook-trout form is at once seen. The same observations apply to the length of the head, which in some well-fed examples, and, in fact, generally in the young raised at Howietoun, is a little shorter in proportion to the length of the body than usual in the brook-trout, but this changes on their being transferred to a new home.

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* Others have likewise stocked pieces of water with these fish, but with varying success. Thus Knox ('Lone Glens of Scotland,' 1854) remarked upon "the artificial Lake of Prestmannan, into which, some years ago, the beauteous Trout of Loch Leven had been introduced. Under circumstances highly disadvantageous they throve, notwithstanding, tolerably well, and even bred at the entrance of a small stream which mainly supplies the lake" (p. 35).

As to the length of the rays of the caudal fin* being longer than in the brook-trout, I have been unable to find that such is the case, either in specimens from Howietoun, from Loch Leven, or in those in the British Museum, as they seem to be absolutely identical in the two forms. In a skeleton of a female 20 inches long, I find the middle caudal ray is 2·1 inches in length, and the longest outer ray 2·9 inches; but were Dr. Günther's figures, as noted below, to be applicable to these fish, the outer ray should be 4·1 inches in length. Such proportions I have never seen in any of the thousands of these fish I have observed at Howietoun or elsewhere, not omitting those in the British Museum. Specimens having the angle of this fin pointed would appear to be young fish, often males, kept, as at Howietoun, where they are not disturbed; but in the old fishes this fin is invariably rounded at its posterior extremity.

The statement that the pectoral fin is pointed is partially correct in small specimens, as it also is in small brook-trout, but in old and well-preserved examples it is as rounded as in other races of freshwater trout †.

As to the male having no knob on the lower jaw, that likewise is a most erroneous assertion *; in the one figured as a diagram, which measures 14·6 inches in length, and was 44 months old when caught in October 1886, the knob is very well developed. This knob is constantly seen in all old males of this form; while even in some old females at Howietoun a small one is occasionally perceptible.

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* "In specimens 13 inches long, the middle caudal rays are not quite half as long as the outer ones, and in older ones they are half as long." (*Günther.*) In a specimen 13½ inches long the middle caudal ray was 1 inch in length and the outer or longest one 1⅞.

† In order to demonstrate this, dried examples of the pectoral fin taken from fishes of this race at various ages were shown at the Meeting when the paper was read.

As to the maxillary bone being "much narrower and more feeble than in *S. fario*, in specimens 13 inches long it extends to below the hinder margin of the orbit, and at no age does it reach beyond it" (*Günther*), Is this so? This statement as to where the maxillary bone extends posteriorly, first made by Dr. Günther, is not borne out by an inspection of Howietoun fish, in which in large specimens it extends from one to two diameters of the orbit posterior to the eye, and this is of normal occurrence. In an example 26 inches long it reaches to 1½ diameter of the orbit behind the eye; the longest fish in that establishment having a total length of 27 inches. For as they become more or less sterile at from 8 to 10 years of age, to which breeding males rarely if ever attain, older fishes are not present.

Doubtless the maxilla and teeth with which it is armed are not so strong at Howietoun as in some (not all) brook-trout of the same size; and the cause of this feebleness in the jaws, which ceases under altered conditions, is immaterial to discuss, because we have no evidence pointing as to how it first commenced. Although perhaps it may be likened to what is seen in some sea-trout, it may also be observed in many loch-trout in the north of Scotland, with whose jaws I have compared those of the Loch-Leven fishes. The question, in fact, now is, what will be the result on the form and strength of the jaws and teeth when these fishes are transferred to a new locality to battle their own way in the world? Anyhow, figures of the comparative strength of the jaws in a Loch-Leven female trout and one of the brook-trout of the same size and sex as published by Dr. Günther are very misleading; for I cannot find such examples in the British-Museum collection showing what he has represented, neither can I in nature *.

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* Since this paper was read, the following observation appeared in the 'Birmingham Daily Post' of Dec. 11, illustrating how erroneous statements as to specific differences in species may give rise to a possibly false conclusion:—"The big trout which was recently captured in the Birmingham Corporation Reservoir at Shustoke has been mounted by Cooper, of London, and may be seen, during next week, at Keeling's fishing-tackle shop, Digbeth. It weighed when caught 8½ lb., and its length was 27 inches. The formation of the lower jaw shows that it was an old fish, and not one of the Loch-Leven trout with which the reservoir was stocked three years ago."

Having thus seen that in its external form either the differences which have been stated to exist between this fish and the brook-trout are erroneous, or else liable to alteration when the fish is removed to another locality, all must allow that such non-persistent differences are no basis upon which to found a species.

As to external colour, we find Parnell asserting, as among its specific characters, "body without red spots;" and that these fish are generally seen without them up to a certain age is of very common occurrence, they being of a grey colour densely spotted with black, and if males, with the fins almost black. At Howietoun, three main types of colour are observable amongst these fish—a slaty or greenish grey, becoming lighter beneath, and the upper two thirds of the body and dorsal fin spotted with black, and the fins generally greyish black. This form of colour is prevalent up to the end of the fourth season, and may almost be looked upon as equivalent to the silvery stage of the salmon smolt or grilse, but I have never seen one over four years of age continuing this livery. The second † or adult form is of a general purplish golden, densely covered with black spots, among which some red ones are usually to be seen, and many old females get a dark line along the middle of the belly, which, as well as the under surface of the head, is more or less black in males. In one female 18 inches long, on November 24th, three bright orange spots were present on the adipose dorsal fin, which as a rule is of a lead-colour, with two or three black spots ‡. The third form, which will have to be again referred to, consists of small under-

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* Specimens and diagrams were shown at the Meeting.

† When old enough to feed on clams, which are about the size of marbles, this yellow colour shows itself. In some small examples, hatched in 1883, the "finger-marks" were very distinct on netting the pond at the end of November 1886.

‡ We must not forget that brook-trout vary greatly in colour even when in the same locality; thus "Ephemera" in 1853 remarked of those in the Wandle that such as "feed under the cover of the trees, or lie *perdu* under banks or artificial 'hides' during sunshine, are dark brown and yellow; those that frequent the unshaded streams with a clear sandy bottom are of a silvery hue" (p. 274).

sized fish, which, owing to sickness or some other cause, have the colours of the brook-trout, with orange-tipped adipose dorsal fins.

The question here arises whether these colours are perceptible in these fishes when removed to fresh localities. In the year 1868, the late Mr. McIvor, of the Government Gardens at Ootacamund in the Madras Presidency, succeeded in introducing some Loch-Leven trout and other European fish to that elevated region, where they are or were doing well (see Journal of the Linnean Society, Zoology, vol. xii. p. 562). In January 1876, Mr. Thomas, F.L.S., of the Madras Civil Service, sent me a specimen from the Hills which was 6½ inches long, and on its body were red spots. In this instance it was clear that if a young Loch-Leven trout could assume red spots when removed to Asia, there was no reason why any similar movement in Europe might not occasion the same results.

The assumption of the general colours of the trout in any given locality by introduced breeds is of very common occurrence, at least after the third year. Now this is the period at which the young of the imported forms would be in a condition to be observed by the fisherman, whether angler or netter.

This is generally asserted to be owing to the imported fish having interbred with the local race, and the hybrid (as it is wrongly termed) or mongrel form has the local colours. It is therefore interesting to ascertain whether, were eggs removed to a given spot quite distinct from the waters where the parents reside, the young which emerge from those eggs would retain the colours of their parents or assume those peculiar to the locality; for if this latter occurs, it must be evident that such has been consequent upon local surroundings.

Ten thousand yearlings from Howietoun were turned into Loch Goldenhove, about two miles away, and fed by the same stream which passes through the fish-farm; this loch is nine acres in extent, and averages six feet in depth. In July 1886, I examined some of these introduced fish, and found them of a purplish colour shot with gold, and covered with black ocellated spots, but no red ones. Dorsal fin spotted with black, but without any white edging, its outer surface greyish; a little orange upon the adipose dorsal fin. The colours, in fact, of these fish were not what is seen in the Howietoun ponds, but nearly approaching those in the Loch where they had been placed. A few had some red spots. As the water in the two localities was the same, food would seem to have been the principal reason of this change in colour.

Although the last experiment does not prove very much, it shows that some alteration in colour may follow new environments; but a still more conclusive result as to the change in colour which may take place in these fish under like circumstances has lately occurred in Gloucestershire. The present proprietor of Cowley had two ponds in a wood on his estate, each about an acre in extent, and from the lower of which springs a small stream; these he wished to have stocked with some good kinds of sporting fish. The two ponds are supplied by underground springs, while there is a fall of about 16 feet from the outlet of the upper pond, and a rather greater one from that of the lower where the stream commences. It will thus be apparent that no fish could obtain access from above, neither could they ascend the 16-feet perpendicular fall from the stream to the lower pond. It was determined to try the Loch-Leven trout; so these ponds were drained, mudded, and then puddled with clay.

During December 1884 and January 1885 one thousand yearling Loch-Leven trout were received from Mr. Andrews of Guildford *, and these were placed in the ponds by Mr. Ogden, of Cheltenham. In August this year (1886) I was informed that, it having become necessary to remove these fish to a more suitable locality, they had been capturing them, and very great differences were perceptible both in size and colour among the two sets of fish—those in the upper pond being silvery with a few black spots, whereas those in the lower pond were of a much larger size, covered with spots, and having purple and golden reflections. Having obtained leave, we visited these ponds on August 25, and first examined the temperature of the water by means of thermometers, when we found that they scarcely differed. The lower pond was the deeper, and in it were large quantities of the American weed, *Anacharis Alsinastrum*, also some *Chara*, while on the surface was a considerable amount of the water crowsfoot (*Ranunculus aquatilis*); whereas in the upper pond there were fewer weeds, but some *Pimpinella Saxifraga* was present near its upper end.

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* Mr. Andrews, of Westgate House, Guildford, wrote (September 14, 1886):—"The yearling fish supplied to Mr. Ogden, of Cheltenham, in 1885, were Lochlevens reared from eggs which were sent me from Howietoun. There can be no doubt of their being from ova from Stirling, as they were put in a pond quite distinct from the others on a different water-shed."

It seemed, so far as we could ascertain, that more animal pond-life was present in the lower pond among the greater amount of vegetation, especially the sessile-eyed crustaceans *Gammarus pulex* and water-snails (*Limnæa ovata*, variety *peregra*). These forms were, however, also present in the upper pond, where a small water-newt was also netted. During the month of April this year, when investigating the stream which issues from the lower end of these ponds, I found enormous numbers of tadpoles and the larvæ of Ephemeridæ and their allies.

A fish captured in the upper pond was seven inches long, its colours generally silvery with a golden abdomen, and a few black spots along the sides, three of which were below the lateral line and two on it, as well as three red ones; cheeks silvery yellow, abdomen golden. Some spots on the rayed dorsal fin, which had a white black-based edge at its upper angle; while the ventral and anal fins had a very distinct white black-based edging. Upper and lower rays of caudal fin and the upper end of the adipose dorsal orange-edged. 52 cæcal appendages. A male, but sterile. The appearance of this fish as to colour was, Mr. Ogden observed, similar to the others removed from the pond.

Two fishes were taken from the lower pond, one ten, the other eleven inches long. They were generally purplish, with golden reflections. The side of the body (of one which was most critically examined) from the upper edge of the pectoral fin to and above the lateral line was closely dotted with ocellated black spots, while there were also some red ones, five of which were on the lateral line. Cheeks golden; abdomen golden, becoming white on the chest. Dorsal fin with numerous spots, and a pink black-edged upper angle. Adipose dorsal with a red edge and several black spots. Pectoral and ventral chrome with white edges, base dark. 62 cæcal appendages. A male, with the generative organs well developed. 22 small shells of *Limnæa* in its stomach.

As regards the colour * on the adipose dorsal fin, I examined at Howietoun, on August 15th, 1886, a number of two-year-olds, with the result that there was merely a trace of orange visible in some, but the black white-edged margin to the rayed dorsal and anal fins was not uncommon.

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* An interesting occurrence has taken place at Cowley among these fish, which would seem to prove that Lochlevens throwing back to brook-trout may be consequent upon a diminished supply of food causing deterioration. During the last week in November Mr. Ogden was near this lower pond and saw a large trout rise; so he returned to the house, and having obtained his fishing-tackle, made a cast over it and captured it at the first throw. The fish proved to be 15 oz. in weight and in good condition, but was described to me as having

On July 5th, 1886, I examined the colour of the adipose dorsal fin in many Lochlevens, from pond 9; the first was rising 2-years, and was five inches long. It had two black spots on the adipose dorsal but not a trace of orange, and no red spots on the body. Several more subsequently looked at were the same. Three had a slight orange tinge on the adipose fin, and likewise a few red spots on the body; in fact this fin was orange-tinted in all, wherein red spots existed on the sides, but the presence of these red spots was the exception, not the rule. Passing on to the nursery-ponds, we examined a few undersized Lochlevens which had not fed well; all had their bodies red-spotted and also red on the adipose dorsal fin, while the rayed dorsal had a more distinctly black white-edged margin than was generally seen. Some of the fish had 2, 3, or 4 black spots on this fin. These fish would at once have the brook-trout livery and not pass through the normal silvery stage—a stage, we have been erroneously informed, which is an infallible test of a trout being migratory and sea-going.

Having paid a visit to Mr. Andrews's* well-known fish-cultural establishment at Guildford, I was shown the yearling Lochlevens which had red spots and red edges to the upper margin of the adipose dorsal fin and on each lateral margin of the tail-fin.

Here I must shortly digress to describe a hybrid specimen raised at Howietoun, which possibly affords one of the most convincing proofs that could be adduced of the identity or close

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been nearly black, while it was the largest fish that has been seen. From the fact that this pond lately had had very few fishes in it (they having been removed), a more abundant supply of food was obtainable, and consequently this trout had grown larger and taken on the Loch-Leven trout colours.

* Mr. Andrews (MS., Nov. 1886) finds at Guildford that "eggs of the Loch-Leven trout from Howietoun do very well with him; they are hatched in water coming from chalk, and reared where it comes from a gravelly soil. The young grow more rapidly and are deeper in form than seen at the same age in their native home. The yearlings have the edge of the adipose dorsal fin and sides of the tail-fin red, and there are also some red spots on the body, in common with young of the brook-trout and some reputed as *S. ferox*." Mr. Andrews continues that he "knows of no *unmistakable peculiarities* observable in the foregoing three varieties of British trout;" and I question if any one else is able to point out their existence.

relationship of the Loch-Leven and burn-trout. In November, 1883, some eggs of a Loch-Leven trout were milted from a salmon-parr at Howietoun (which specimen I still possess in spirit), and hatched in March 1884. As I have elsewhere related, most of the young died of dropsy, but a few lived, and some are still at Howietoun in pond 16, very many being small, but a few of fair size, some even giving eggs and milt this season. On November 24th I removed one of these fish, a beautiful parr, showing the long pectorals and large caudal fin of the salmon, but having only nine finger-marks; while as to colours it was of a beautiful silvery glossed with gold, the rayed dorsal fin rather densely spotted with black, some of the spots having a deep scarlet edging, and a white margin with a dark base being present at the front upper corner of this fin as well as of the anal. Adipose dorsal red-edged; caudal straw-coloured, with red upper and lower edges. Numerous black spots in the upper half of the body, also some red ones, but most of the latter along the lateral line and some below it. A large black spot on opercle and some smaller ones.

Here was a hybrid showing the number of bars of the trout, and also most of the trout-colours, but with this remarkable variation from the Loch-Leven breed, that the orange edging was present on the adipose dorsal * and the light edging on the dorsal and anal fins. In fact the spots on the dorsal fin closely resembled those seen in the burn-trout in Sutherlandshire. Unless the Lochlevens have burn-trout blood in them, how could these fish possibly throw back to the colours of the latter race?

It is normal for the adipose fin of the Loch-Leven trout to have black spots upon it, but no orange margin. The reason is probably similar to that which causes these fish to have no orange spots on the body, because if orange spots exist upon the body the adipose dorsal is also orange-tipped. Evidently whatever causes this coloration in one part of the body equally does so in the other.

As to the internal organization of the Loch-Leven trout, we have been told that it possesses from 49 to 90 cæcal appendages, and that the teeth along the body of the vomer "form a single series, and are persistent throughout life." In fact from the time Parnell first ascertained that these trout often possess a larger

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* Not only is the adipose dorsal normally destitute of an orange edging or orange spots in both young salmon and young Lochlevens, but this colouring is present in many sea-trout with which young Lochlevens have been compared.

number of these appendages than are usual in brook-trout until the present day this has been held conclusive evidence as to their specific difference from other forms. Many who would admit that variations in external colour or in that of the flesh, or even alterations in form, may be dependent on local surroundings, will be slow to believe that structural differences are not of much greater value. Hence we must first inquire whether the number of these cæcal pylori are constant in the Loch-Leven race of trout, whether they ever vary in the brook-trout, and, lastly, if any facts can be produced proving them to be inconstant.

Among the local Loch-Leven forms we are told by Parnell that the cæcal pylori are from 60 to 80 in number. Sir J. Richardson found 73 in each of the three which he dissected, and Günther from 49 to 90; and although in the description of the species the latter writer says, "Cæcal pylori normally 60 to 80," he instances seven females in the British-Museum collection as follows:—"Females, from 12 to 18 inches long. Purchased, said to be from Loch Leven. Caught in April. Cæcal pylori 65, 63, 60, 54, 54, 53, 49; vertebræ 58–59. These specimens have the pyloric appendages fewer in number than is generally stated; yet these cæca are so wide—so much wider than in *S. fario*, that the reduction of their number has evidently been caused by a confluence of several cæca into one" (Catal. vi. p. 101).

From the foregoing statements it is evident that the number of these appendages is very variable, for we have them stated as being from 49 to 90. If, however, we turn to the writings of most authors who have counted the cæcal pylori in *S. fario*, we find them enumerated as follows:—"I have never found them to exceed 46" (Parnell, 'Fish Firth of Forth,' p. 308). Thompson in 1836 examined the so-called *S. ferox*, and found in four examples 49, 45, 39, and 36 ('Nat. History of Ireland,' iv. p. 157). Günther among his other five non-migratory freshwater forms enumerated them as varying from 33 to 49.

Having thus shown that these appendages in the Loch-Leven trout have been recorded as between 49 and 90, while in other non-migratory freshwater forms they have been found to be between 33 and 49, I propose enumerating some which I have counted in examples of this fish. Among *males*, in specimens varying from 7 to 20½ inches in length, I have found them as follows:—At Howietoun, 8 examples of fertile fish averaged about 67 cæcal appendages, founded on these numbers—82, 75, 74, 73, 65, 62, 62, 48.

At Cowley, in Gloucestershire, one fertile male had 62, one which was sterile 52. Among *females*, varying in length from 12 to 22 inches, the number of these appendages in 7 examples of fertile fish averaged about 58, derived from the following numbers —66, 64, 62, 59, 57, 55, 45; while one large female from Loch Leven had 47. As a rule these cæca appear to be larger in females than in males, while in one of the latter a single one of these tubes was abnormally shortened near the pylorus.

The foregoing figures show a variation at Howietoun in the number of these appendages, ranging from 48 to 82 in male fish, and from 45 to 66 among female fish; while in one male which was fertile, examined in Gloucestershire, there were 62, and in another, not so well fed, from the same locality, and sterile, there were 52. In only one is the number seen to approach 90 (82) as given by Dr. Günther, and with that exception 75 was the largest number counted, and from that down to 45, clearly showing that this is an unstable character, prone to change, and consequently unsuitable for discriminating species. Also that, away from Loch Leven, these appendages have diminished in number, and still more so in examples from the ova hatched at Guildford and reared in Gloucestershire, where the smallest fish were sterile and had the fewest of these appendages. As to the diameter of the cæca, the difference was not apparent, except so far as I have mentioned above.

Possibly the number of the cæcal appendages may, under certain circumstances, be found of value in ascertaining whether the food on which the fish subsist is of such a nature that they will thrive or deteriorate.

If these appendages decrease when the fish are transferred to other localities, it may be asked if instances can be adduced where they have ever been found to increase in trout when removed to better feeding-grounds or improved conditions of life*. The eggs sent from the brook-trout of Hampshire and Buckinghamshire by Mr. Frank Buckland and Mr. Francis Francis to Tasmania have developed into a large race, in which the cæcal pylori seem to have reached the normal number of 52, showing a considerable augmentation, and again proving the number of these organs to be inconstant.

Respecting the vomerine teeth being in a single series in Loch-

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* Since this paper was read (viz. in March 1887) young rainbow-trout (*Salmo iridens*), 22 months old, raised at Howietoun, have been examined. In California, whence the eggs were received, these fish are said to possess about 40 cæcal appendages; in one dissected at Howietoun I found 71.

Leven trout, but in a double row in burn-trout of the same size, we have first to consider whether the facts as stated are correct. All trout and salmon (not charr) when young, irrespective of the teeth on the head of the vomer, have a double row along its body; but these in all are dependent on age or rapidity of growth, and fall out, commencing behind and extending forwards. In salmon and sea-trout, which are forms that grow most rapidly, these teeth are shed the earliest, while the Loch-Leven trout, which is likewise a rapid grower, loses them rather sooner than the burn or loch form; hence to say that in the mature examples they *are invariably* in a single row is erroneous. At the same time it is not here advanced that rapidity of growth is the sole cause of this, for the deciduousness of the teeth appears to be owing to the absorption or narrowing of the tooth-bearing ridge on the vomer, in consequence of which the teeth, originally placed in pairs, become ultimately ranged in a single row and finally fall out.

The condition of the vomerine dental system in specimens of Loch-Leven trout may be thus recorded:—(1) ♀ 20 inches long, 2 teeth exist on the hind edge of the head of the vomer, and 3 along the front half of its body, the first two of which are almost opposite one another. (2) ♂ 9 inches long, 2 teeth at hind edge of vomer, 2 at the front end of the shaft, and 7 in an irregular zigzag line, almost in one continuous row, while their points turn alternately to the right and left. (3) ♀ 10·9 inches long, 2 at hind edge of head of bone, 2 in a line at the commencement of the body, and 8 as in the last but more distinctly in pairs. (4) ♀ 13·5 inches long, 2 at hind edge of head of vomer, then 4 in a single row, next a pair turning one to each side, and lastly 4 more single ones. (5) ♂ 14 inches long, 2 teeth at hind edge of head of vomer, 9 in a single row along the body of that bone; of these the two central ones form a pair. (6) ♀ 19·2 inches long, 4 teeth at hind edge of body of the vomer, 12 along the body, among which are three pairs. (7) ♀ 23 inches long, 3 at hind edge of head of vomer, 8 along its body in a single row, some turning one way and some another. The foregoing seven specimens show that it is by no means an invariable rule that all the teeth along the body of the vomer are in a single row.

Having examined a considerable number of burn or loch trout in Sutherlandshire, I found that the maxillæ were not stronger than in the Lochlevens, while a specimen * taken at random shows the same dentition as in the form under discussion: burn-trout, ♂ 11 inches long, 2 teeth at the hind edge of the head of the vomer, 10 in almost a single line along the body of that bone, turning alternately right and left at their points, but in only one instance are they in a pair. Further south, as in the Windrush in Gloucestershire, the maxillæ are stronger and the vomerine teeth are more nearly in a double line than in more northern specimens; but an entire series, showing all these grades of variation, may be traced in freshwater trout in most localities where I have searched for it.

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* Exhibited when the paper was read.

The colour of the flesh of the Loch-Leven trout is said to be deep red, and it is reputed to be very good eating. Whether the flavour of these fish has or has not deteriorated since the partial draining of the lake, as asserted by some and contradicted by others, must ever remain unsolved, because how the fish were cooked, the degree of hunger in the partakers of the food, and many other circumstances would have also to be taken into account; while deciding such a question from recollection would be a rather doubtful proceeding. There is a legend that in olden times these fish never took a fly; and an anonymous writer in 1886, commenting upon the bad luck which had attended an angling competition, observed that fly-fishing on Loch Leven had been in existence for about 25 years, but previous to that time these fish showed no disposition for winged prey. Granting the general accuracy of this statement would seem to partially confirm the opinion of Parnell and some others, that the local food has diminished in amount, and therefore these fish will now take the fly. Why the charr has disappeared from this lake is not material to the present inquiry.

As food Parnell held that at Loch Leven the flesh of this form of trout is of a dark red, but in the common loch or burn-trout pinkish or often white. This, however, cannot be held as distinctive of species, for some trout captured on the same day at Loch Assynt, in Sutherlandshire, showed all variations in the colour of their flesh, from white to red, and were all equally well tasted. Parnell also observed that "James Stuart Monteith, Esq., of Closeburn, caught a number of small river-trout, and transferred them to a lake (Loch Ettrick), where they grew rapidly; their flesh, which previously exhibited a white chalky appearance, became in a short time of a deep red, while their external appearance remained the same from the time they were first put in" (*op. cit.* p. 307).

Mr. Ffennell, writing of the Lochlevens at Mr. Andrews's (*Times*, Oct. 14th, 1886), observed that "the Loch-Leven trout were no strangers to me; I have killed many, and as a fresh-water fish I hold them in high esteem: and I certainly think that those I took from the roadside pond in Surrey were the very best I had ever placed before me."

The question whether the Loch-Leven trout is a local race or a distinct species, is one of considerable practical importance to the fish-culturists of this country, quite irrespective of its scientific interest. If it is a species distinct from the brook-trout, its introduction into our streams and dissemination through our fresh waters would be a great source of hybridization among our indigenous forms, and this would tend towards sterility of the offspring. On the other hand, if it is merely a local race, its crossing with the brook-trout would be merely the interbreeding between two varieties of one species, which, instead of being a cause of sterility, is more commonly a means of improving a breed.

I assume it as granted that the Howietoun fish are in every respect similar to those of Loch Leven, whence the breed was derived. This variety is sometimes, not always, finer shaped towards the tail, and has a rather shorter head, as in the sea-trout, *S. albus*, than the ordinary brook-trout, while its form is much like that of the *Salmo lemanus* or loch-trout of the Lake of Geneva and elsewhere, which has been shown to be a variety of *S. fario*. Its maxillary bones are somewhat finer than in our ordinary river-trout; its cæcal appendages are more numerous; and its colour differs, being as a rule silvery with black, but having no red spots up to its fourth or fifth year. Dr. Günther's observations that the male never has a knob on the lower jaw, that its fins are never rounded, that the teeth along the body of the vomer are always in a single row, very different from those of the brook or burn trout, may be dismissed as erroneous statements, probably made owing to the want of opportunity of examining specimens. The Loch-Leven trout is doubtless a rapid grower in its northern home, and the race at Howietoun has been much improved by selection of breeders; but removing the eggs to a new locality and then rearing the young has shown that the form and colour of the local race of trout is, as a rule, assumed, while even the number of cæcal appendages becomes altered, owing to changed condition of life.

The Natural History of the Genus *Dero*. By EDWARD C. BOUSFIELD, L.R.C.P. Lond. (Communicated by Dr. J. MURIE, F.L.S.)

[Read 4th November, 1886.]

(PLATES III.-V.)

AT the meeting of the British Association in 1885, at the request of Prof. McIntosh, I presented a summary of the results of my study of the Annelids of the genus *Dero*, with descriptions of some new species which had come under my notice, and remarks as to the identification of others. From the necessary limits of such a communication, I was compelled to omit much detail; and lack of time and material led to a certain want of accuracy in my collation of the work of other writers, and the comparison of the examples which came under my own notice with their descriptions.

Enlarged facilities of reference having now enabled me to acquire a tolerably complete knowledge of all that has hitherto been written on this genus, and a considerable supply of material from various sources having given opportunities for extended observation and closer comparison, I venture to offer the following as the most complete account of the genus allowed by the present state of knowledge. Four new species having been met with in the course of the eighteen months or more during which I have been working at these Annelids, it would appear probable that others still remain to be discovered; and it is to be hoped that the publication of a summary of what has at present been accomplished may facilitate future observation.

History and Bibliography.

The Annelids with which this paper deals, though their bibliography covers a period of a century and a quarter, have hitherto been the subject of very little original work, owing probably to their habits of life, which prevent their presence in a state of nature from being easily discovered. In view of the great advances which have been made in methods of research, and especially in optical appliances, the very evident way in which the observations of earlier writers, and their interpretations (not unfrequently erroneous), have been copied by later authors, in many cases almost *verbatim et literatim*, is not a little surprising.

The first description of any species of *Dero* is to be found in the 'Insecten-Belustigung,' iii. Theil, of Rösel von Rosenhof (24*), published in 1755. Several figures and a lengthy description are there given of a species identical with *Dero furcata*, under the name of "das geschmeidige Wasserschlänglein mit zwey Gabelspizen." The remarkable feature of Rösel's account is the moniliform arrangement of the two long palpi by which this species is distinguished, which he described. This character has not been noticed by Grebincky, Semper, or myself; but the explanation is not far to seek. One of the first signs of approaching dissolution in the Naid family is the separation of the cuticle from the cells of the epidermis, with formation of *bullæ*; and under these circumstances something of the kind has been observed by the writer. It is somewhat curious that up to 1877, when the last description of this species was written, every observer who described the form gave it a fresh name; so that it has received trivial names from its discoverer and from Müller, and scientific ones from Oken, Grebincky, Leidy, and Semper. Rösel observed the process of transverse fission in an advanced stage, and described it as a "curious method of copulation." He also described the result of transverse sections of the worm.

Following Rösel, the distinguished naturalist O. F. Müller (18), in 1771, gave a remarkably excellent account of one or two species; all the main features having been grasped, and the branchial processes (the characteristic feature of the genus) having had their proper function assigned to them. In specific characters, however, Müller was less fortunate; and to him must be given the blame of the confusion in the nomenclature of the genus which so long existed. In consequence of the small scale on which his figures are drawn, there is great difficulty in identifying the species represented; but two, if not three, distinct ones are certainly shown, all being included under the general name of *Nais digitata*. Rösel's species is recognized as distinct, and named "the eyeless Naid with pronged tail," the other being called "the blind Naid with fingered tail." The distinction thus formulated is too slender to enable me to decide as to the specific differences; and in view of the impossibility of ascertaining the particular species to which Müller intended to apply the name *digitata*, there seems to be no better course open than to entirely reject it. Up to the present time the name is occasionally used on the Continent; but as the worm designated may be any one of three species at least, and as no clear definite description has yet been given of any of these in particular under the name in question, this cannot be used as an argument against the course proposed.

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* The numbers in brackets refer to the Bibliography, p. 106.

In acknowledgment of Müller's work, I have attached his own name to the last new species discovered.

The name by which the genus is now known was bestowed upon it by Oken (20) in 1815, and the species described by Rösel distinguished as *Dero furcata*, Müller's appellation being retained for the other species. This was apparently the extent of Oken's knowledge of the genus, as his figure was taken from Müller, and his diagnosis is as scanty as possible.

Dutrochet (9) rediscovered the genus, and being ignorant of the work of earlier writers, renamed it *Xantho*, remarking that it appeared either not to have been observed before or to have been confounded with *Nais*. He also described the branchial funnel as an organ of progression and retrogression and of prehension; the branchial processes being spoken of as veritable non-articulated limbs, resembling the feet of cephalopodous Mollusca and the arms of the polyps! The number of branchial processes is given as ten in one species and six in another, to which the names *Xantho decapoda* and *X. hexapoda* are respectively given. As the figures which accompanied the original paper appear to have been lost, any attempt to identify Dutrochet's species must be mere guesswork.

Blainville (1) gave a somewhat unintelligible account of two species, named *Nais digitata* and *N. decapoda*. The former is credited with the possession of six *pairs* of fleshy lobes, the latter with five, reference being also made to a drawing in the 'Encyclopédie Méthodique' of a species with no less than eight pairs. Having had an opportunity of examining the latter work, I found that the plate in question is merely a *replica* of Müller's (18); while the peculiarly unmethodical character of the arrangement of the text renders any search for the article referring to the figures hopeless. However, as none of Müller's figures show more than four pairs of lobes, Blainville has evidently interpreted them wrongly.

Blainville (2) in a second article in the 'Dictionnaire des Sciences naturelles' and a writer in 'Rees's Cyclopædia' (23) quoted from

Fabricius the description of a worm which he described as *Nais quadricuspida*, which appears to have some affinity with the genus *Dero*. Apparently this species has not since been observed, though from the description given by Fabricius (10) it seems sufficiently well marked *.

Gervais (11) reclassified the Naïdidæ, and renamed the genus *Dero*; *Uronaïs* being the designation applied to it, apparently from the peculiarity of the tail. He appears to have been the first to remark that Müller's figures evidently represented two distinct species. In common with some other writers, he included the *Nais barbata* of Müller, in spite of the fact that the latter is described as having a simple truncated tail.

Œrsted (19) gave only a very short account of the genus, calling it *Proto* (Oken).

Grube (12), whilst contributing little or nothing to our knowledge of the genus, made some interesting remarks on its systematic position, and referred to two marine forms, described by Dujardin (8) and Dugès (7) respectively, which he regarded as allied to *Dero*. Having carefully compared the papers referred to by Grube, I am unable to agree with his conclusion. Grube also remarked on the confusion in the nomenclature, professing himself unable to decide the question of the origin of the name *Proto* †. It should be remarked that Grube does not mention having seen *Dero*.

Bosc (4) mentioned, under the name of *Nais auricularis*, a worm found in Carolina with a tail formed by a large tubercle, in the middle of which is the anus,—a description which would well apply to a *Dero* in a contracted state.

Pennant (21), Shaw (27), Stewart (28), and Turton (30) gave descriptions of *Nais digitata* which afford no assistance in identifying the form; and the same may be said of a long paper by Houghton (13), who, having found the genus in England, instead of observing it for himself, did little more than copy Müller's description. Johnston (14) merely mentions the genus to throw doubt on its right to a position in the British fauna at all.

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* "Nais verrucis lateralibus bifidis setosis cirris abdominalibus et caudâ quadrifidâ."

† The origin of this name remains unknown. Œrsted attributed it to Oken, in whose work no trace of it is to be found; nor is it likely that he would have given to one genus two different names. Another writer, in spite of Grube's remark, attributed the name to him. The only feasible explanation appears to be that some unknown writer, between the time of Gervais and Œrsted (*i. e.* 1838 and 1843), originated it in a paper which has been lost. The 'Nomenclator Zoologicus' of Agassiz gives both names, and attributes both to Oken, but evidently wrongly. The etymology is there given as *δέρω, cutem exuo.*

In 1855, for the first time since Müller noticed the genus under consideration, we meet with an attempt to give something like an exact account of a new species. In that year a paper appeared from the pen of D'Udekem (6), which must be regarded as the starting-point of all modern work on the subject. Up to that time *Dero digitata* and *D. furcata* (the latter of which had almost been lost sight of) had held the field alone; but D'Udekem's contribution contained a description of a new species, *Dero obtusa*, clearly expressed, and accompanied by a figure which rendered it easily recognizable.

In 1872 Perrier (22) published a very interesting and exhaustive account of a species which he identified with that described by D'Udekem; and the fact that he was wrong on this point in no way detracts from the value of his observations, whilst his figures are almost all that could be desired. In acknowledgment of Perrier's work, I have named the species which he studied *Dero Perrieri*, it being new.

Prof. Leidy (15), in a paper of which he has kindly sent me a reprint, describes two worms, one of which he calls *Dero limosa* and the other *Aulophorus vagus*. The former appears to be identical with a species found abundantly round London; the latter is considered by Prof. Leidy to be identical with that described by Rösel (*loc. cit.*), the *Dero furcata* of Oken; and apparently Prof. Leidy's distinction is based upon the fact that he found the latter free.

Semper (26) has described two species under new names, his *Dero philippinensis* being apparently the same as *Dero limosa* just referred to, whilst *Dero Rodriguezii* is undoubtedly the same as the *Aulophorus vagus* of Leidy, *Dero furcata* of Oken, and *Dero palpigera* of Grebincky.

Tauber's work (29) contributes nothing to our knowledge of the genus, being merely a catalogue of Danish Annulata. He remarked that the genus is rare in Denmark.

The magnificent work of the Bohemian Professor Vejdovsky (31) contains a full list of names and synonyms of the species of *Dero* known up to the date of his publication. Unfortunately he observed only a very few examples of the genus, the species being one which he identifies with *Dero digitata*. As there is, however, an absence of anything like a diagnostic description of the species in question, the identity of *Dero digitata* is still, and probably will remain, unsettled.

The last contribution to the literature of the subject is the abstract of a paper read by me at the Aberdeen Meeting of the British Association (5). The conclusions therein arrived at hold good only in so far as they are corroborated by the present communication.

Habits, and Methods of Observation.

The species of the genus *Dero*, with the doubtful exception of the form described by Fabricius in 1778, are all freshwater dwellers. They pass their lives entirely below the water-level in tubes which they secrete, and into the composition of which foreign matter does not enter. The tubes are as a rule either constructed in the mud, or along the stems of aquatic plants, or even within decayed stalks.

To this method of life is probably owing the small amount of attention which the genus has attracted. If, however, these worms be present in any locality, they may be easily detected as follows:—

A portion of the mud, within an inch of its surface, is placed in a bottle to about the depth of half an inch and water added. After the mud has subsided the bottle is allowed to stand for about 12 hours, when, if any samples of *Dero* be present, they will have constructed their tubes in contact with the glass, either in the mud or on the sides of the bottle, and may be removed for examination by pressing on the end *from which the head protrudes* (as the tail is very easily injured) with a camel-hair pencil. Under this treatment the worm backs rapidly out of the tube, and may be readily secured with a pipette. The species of the genus *Dero* are sociable in their habits, as many as half a dozen tubes being often placed side by side, and it is quite the exception to find single ones.

Having secured the worm, the question arises how best to examine it. It is almost impossible to determine the species of any given example when ordinary methods, such as the compressorium or the live-trough, are alone employed. In the first case the pressure, even if slight, prevents that full expansion of the branchial area which is absolutely necessary for exact observation; whilst in the second case the restlessness of the worm is so great that it can only be kept in the field of a power too low for needful details to be made out.

For general observation the method which I have found most suitable is to transfer the worms to a live-trough, with a sufficient depth of mud for them to form their tubes (about $\frac{1}{4}$ inch), when they may be observed under perfectly natural conditions; the hinder end of the worm, carrying the respiratory apparatus, being kept protruded upward, whilst the head is occupied below in ingesting the mud which forms the food of these creatures. If the tubes have been formed amid vegetable *débris*, the best plan is to secure a portion in the compressorium under slight pressure, or in a small zoophyte-trough, when powers as high as Zeiss's B B or an English $\frac{2}{3}$-in. may easily be employed. To make out the histological details, nothing is better than the cotton-wool trap used for wandering Rotifera; with this and a judiciously regulated pressure, a $\frac{1}{10}$-in. objective may be safely used. The form of compressorium adopted by me is that known as Beck's parallel compressorium, and I have found nothing to equal it for the facilities it offers of increasing or diminishing pressure without removal, and of viewing an object on both sides.

General Characters.

In general outline the species of *Dero* closely resemble their relatives of the genus *Nais*. The following marked differences, however, obtain :—

1. They are destitute of eyes.
2. They are furnished with decidedly red blood.
3. The perivisceral fluid is devoid of corpuscles.
4. They inhabit fixed tubes.
5. They possess a highly specialized respiratory organ on the last segment of the body.

The general form of the body is more or less cylindrical, the head being obtusely pointed. The thickness gradually increases from the head for about two fifths of the length of the worm, after which it diminishes gradually again, being narrowest in the last segment but one.

As in *Nais*, the mouth-segment is destitute of organs of motion, whilst the four following have them only on the ventral surface *.

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* Except *Dero furcata*, of which see description.

These organs are known as setæ, their form being more or less that shown in Pl. IV. fig. 10 and Pl. V. fig. 16, curved like a long *f*, with a central shoulder and bifurcate outer end. Each of the bristle-bundles in the first four ventral pairs contains from four to six such setæ, in length considerably exceeding those of the body generally, though there is but little difference in the general form.

In the dorsal bristle-bundles, the first pair of which is found in the sixth segment, bristles of two forms are found. The first and most evident are tapering, projecting through the epidermis to a distance about equal to the diameter of the worm, and of these one is found in each bundle. The second are short, stout, notched at the outer extremity, and barely penetrate the skin. Notwithstanding their inferior length they are always the first developed, and if there should by chance be two tapering bristles in a bundle, each of them is accompanined by its own shorter one.

The developmental relation between these two forms was pointed out by Perrier, and is additionally proved by the fact that in the posterior segments the tapering bristles are altogether wanting, the short ones alone remaining; these at length are reduced to mere points in the last few segments, and finally disappear.

Illustrations of the various forms of setæ will be found in the figures already referred to.

The integument of the worm is smooth, and shows but few palpocils, except at the head and tail, and even there not many; they are connected with pyriform cells in the epidermis in the manner described by me in a previous paper [*].

The digestive canal conforms closely to the Naid type in its exsertile proboscis, its pharynx beset with mucous glands, and its long pharynx dilated at one point to form a gastric enlargement, passing on into an intestine, capacious, closely beset with the so-called hepatic cells, and having a very strong inward ciliary current for a great part of its length. The segmental organs, which begin in the sixth segment, are essentially simple convoluted tubes with very narrow *lumen*, the dilated inner extremity being thickly clothed with fine short cilia. The external condition of these organs varies greatly. Frequently they are as described above, without any appendages. In other instances in the same species, at the same period of the year,

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[*] "On *Slavina* and *Ophidonais*," Journ. Linn. Soc., Zool. vol. xix. p. 265, 1886.

they are embedded, except for a short distance at each end, in a mass of large, clear, spheroidal cells. When these masses are not found on the segmental organs, they may occur on the septa between the segments, or they may be absent altogether. I have, however, been unable to discover the conditions which govern their appearance.

It has been stated that the internal end of the segmental organs is a ciliated funnel; they end externally in a somewhat dilated portion, which communicates freely with the surrounding element. Their function appears to be purely mechanical—that of preventing undue distention of the body by the fluid which passes through the wall of the intestine, and is doubtless charged with effete material from the blood-vessels which run in contact with it. Accordingly I find that, contrary to the general accepted opinion, the lumen of the tube of the segmental organ is not ciliated, but that along one side of it is attached a membrane whose undulations have the effect of driving the contained fluid in an outward direction. During full activity it is not easy to see the edge of the membrane, though the character of the movement even then is such as to suggest some action quite different from that of cilia, and much more nearly resembling that seen in the vibratile tags of the rotifers.

When vitality is at a low ebb, it is by no means difficult, with a power of about 800 diameters and suitable illumination, to see the edge of the membrane. The same conditions exist in the case of other Oligochæta, and indeed it is not easy to see how cilia could act to advantage in a tube of such extremely small calibre, nor am I aware of any instance in other forms of animal life where such is the case [*].

The nervous system of *Dero* is excessively difficult to make out, but appears to closely resemble that of *Nais* in its arrangement. Perrier's account of the species which he observed stops short at this point, his description being very meagre, and in the few details given there is nothing to indicate any special arrangement.

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[*] The observations which led to the above conclusions were made on *Tubifex*, *Dero*, *Nais*, *Stylaria*, *Chætogaster*, and *Æolosoma*. In the case of *Chætogaster* only was there any difference. In the latter genus I have never seen any movement whatever in the tubular portion of the segmental organs, but on one occasion observed in connection therewith an organ exactly resembling the vibratile tags already referred to.

Branchial Area and Circulatory System.

The branchial apparatus is by far the most important character of *Dero*. Though it is found in a modified form in the *Aulophorus* of Schmarda (25), yet in its full development it is present only in the genus under notice. In all the Oligochæta a strong inward current is visible in the hinder part of the intestine, which no doubt subserves a respiratory purpose, as it commences at the point where the arterial system receives the blood from the venous; and at this point, if nowhere else, both vessels run in close contact with, or are embedded in, the intestinal wall, so that the most favourable conditions for interchange are combined. In those forms which live and move free in the water, this is doubtless sufficient provision for their needs; but in the case of *Dero*, which, though not fixed, is yet stationary, a special provision seems required, such as is found in the branchial area.

This is essentially, and in its simplest aspect, an opening-out of the hinder part of the intestine, supported by a layer of epidermis, the space between the two being occupied by muscular elements and blood-vessels. Figs. 4 and 5 in Pl. IV. (the former taken from Perrier's monograph, the latter from life) will show the general arrangement. In fig. 5, which gives the area in section, the relative proportions between its two constituents are shown by the shading, the dark portion being integumental, whilst the light shading indicates the continuation of the mucous membrane of the intestine, which supplies the respiratory element. The form of the area differs in different species; but in all cases a number of branchial processes arise from the floor of it, their number being four and *no more*. This may seem a surprising statement, in view of the considerably greater number, *eight pairs* according to one writer already referred to, which have previously been described. Reference has already been made to the difficulty of determining the species of any given example of the genus, and similar difficulties, not overcome, have been the cause of the remarkable divergencies and discrepancies to be found in the descriptions heretofore given. These have obtained down to the latest period: thus both Semper and Leidy have described appearances which can easily be reproduced, but which are not by any means normal. If an apology be needed for such an assertion, I hope it will be found in the fact that I have devoted myself almost exclusively to the study of this genus for nearly two years, have examined hundreds of examples of its various species, and have done my utmost to make sure of every fact which I advance. It is true that in three species supplementary branchiæ are present, but these are much smaller than the primary ones, and are always placed at the angles of the dorsal lip of the area. Where more than three pairs are attributed to any species, the incurved margins of the area, which are ciliated on both surfaces, have been mistaken for additional branchiæ.

The integumental and mucous layers of the area are not equally extensive; the mucous layer is wanting (Pl. IV. fig. 5) at the tip, and encroaches on the margin of the integumental layer at every other part. The branchiæ are simple elevations of the mucous layer, containing loops of blood-vessels one in each, and are lined by a layer of stellate muscle-cells continuous with the layer which underlies the mucous membrane of all the other portions of the area. This muscular network is capable of great expansion and contraction, and in the latter condition fully realizes Bosc's description of *Nais auricularis*. The area is extremely sensitive, the slightest jar causing contraction, and, what is somewhat remarkable, it appears to be endowed with sensibility to actinic light *.

In some species, in addition to the muscular network of stellate cells already spoken of, an arrangement of radiating cells, spindle-shaped, with forked extremities and a central nucleus, is found connecting the dorsal lip of the branchial area with the intestine beneath it.

In most cases the branchial area is concave in full dilatation; but in *Dero Mülleri* it is capable of such expansion as to become altogether convex, and to stand at right angles to the axis of the body. The same is the case to a less extent in *D. latissima*.

The chief blood-vessels are, as usual, two in number, a dorsal (arterial) and a ventral (venous). The dorsal vessel in *Dero* can only be so called for convenience; since for the greater part of its length it runs along the side or lower part of the intestine embedded in its wall, only becoming free when it reaches the junction of the latter with the stomach. From this point it is connected by a varying number of contractile loops with the ventral vessel, and terminates exactly as in *Nais*. In the branchial area the circulation between the dorsal and ventral vessels is carried on as follows:—The abdominal vessel, running backward undivided to the boundary of the mucous layer of the area, divides into two branches which run right and left round its margin. Each of these main branches gives off at least three secondary ones, one to each of the branchia of its own side, which runs to its summit and down again without breaking up into a capillary network; whilst the third, also undivided, runs obliquely across the area, the continuation of the main branch running on round the margin. All these branches again unite to form a common trunk, which joins with a similar one from the opposite side to form the commencement of the dorsal vessel.

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* I have several times tried to photograph the tail of *Dero*, but hitherto with small success, the ignition of the magnesium-ribbon employed as the source of light causing contraction in nearly every case. The same phenomenon occurs in *Hydra*. In order to overcome this difficulty a drop-shutter was placed between the source of the light and the object, but the result was the same; and the marvellous rapidity of the contraction was shown by the fact that, although fully expanded up to the instant of exposure, the photograph in every case showed the polyp in a contracted condition.

The specialization of the termination of the hinder portion of the intestine does not appear to have any effect in abrogating the general respiratory function of that tube; doubtless an advantage to these worms, which spend so large a portion of their lives in crawling in the mud in search of food. It should be remarked that the tube is much too narrow to admit of the branchial area being drawn into it when expanded; nor is the tube wide enough to give room for the bristles, the latter being always much curved when within it; and though the worm is able, as a rule, to turn round with facility, yet it sometimes happens that it becomes fixed in the tube in so doing, and is quite unable to extricate itself.

Distribution of Species.

With the exception of *Dero Mülleri*, received from Mr. Bolton, of Birmingham, I have found all the known forms within a short distance of London. The richest hunting-grounds are without doubt the tanks at Kew and at the Royal Botanic Society's Gardens, Regent's Park. The latter locality has furnished a species, the only one whose indigenous character is doubtful, viz. the beautiful *D. furcata*, the finding of which and the difficulty of obtaining any reliable information about it, first led the writer to undertake the study of this genus. Here also he first found

D. latissima, as also in a pond between Sutton and Redhill on the high road, and later *D. limosa*. The latter is especially abundant in the Lily-tank at Kew. *D. obtusa* and *D. Perrieri* are to be found in the large pond on Wandsworth Common; and both species, as well as *D. latissima* and the rare *D. acuta*, have been found in the pond at Greenwich Park. The last-named species was also found for the first time by my wife in the Crystal-Palace basin.

Abroad the only species known to have been found are *D. furcata*, *D. limosa*, *D. obtusa* (Belgium only), and the doubtful *D. digitata*. Of these, the first two are widely distributed, ranging from the United States to South Russia and the Philippine Islands. It will be seen, therefore, that at present the British Isles are apparently by far the richest in species of any known locality. Others doubtless remain to be discovered; and to this end I am anxious to obtain samples of mud in a moist state from various localities abroad *; and South America especially should prove fertile in this direction. Much remains to be done before our knowledge of the minute Oligochæta can be considered even fairly complete; and it is quite possible that systematic observations in tropical and subtropical regions would reveal forms still more interesting and remarkable than those included in the genus *Dero*.

My thanks are due to Mr. T. Bolton, whose kindness in supplying me with specimens has resulted in the discovery of one new species which has not yet been found elsewhere.

The following is a systematic account of the various species at present known.

Family NAIDOMORPHA, *Vejdovsky*.

Genus DERO, *Oken*.

Proto.—Xantho, *Dutrochet*.—Nais digitata, *Müller*.

Char. Minute Annelids of from 40 to 100 segments, red-blooded, eye-less, inhabiting tubes secreted from the body, without aggregation of foreign material. The last segment bears an expansion from which arise four processes. Perivisceral fluid free from

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* I shall be much obliged for samples from any freshwater lake, pond, or tank, or even slow stream abroad. The best time for collecting would probably be before the rainy season in such localities as have one; in those which have not, probably the end of summer would be best. The samples may be sent to me, care of the Linnean Society.

corpuscles. First five segments destitute of dorsal setæ; the sixth and following having both dorsal and ventral setæ, the latter hooked, the former straight, and one forked bristle in each bundle. Contractile loops in the sixth and some following segments, one in each.

a. Without secondary branchiæ.

1. **Dero latissima**, *Bousfield* (5). Pl. IV. fig. 8.

Segments 30–40. Contractile loops 4. The branchial area with entire margin, well developed, width in full expansion exceeding length, capable of complete eversion, then becoming convex. Branchiæ long, well developed, plano-cylindrical.

2. **Dero Perrieri**, *Bousfield*. Pl. IV. figs. 4–7.

Dero obtusa, *Perrier* (22).

Segments 25–35. Contractile loops 3–5. Branchial area with entire margin, trefoil-shaped in full expansion. Branchial processes well developed, cylindrical, the posterior pair longer than the anterior.

3. **Dero obtusa**, *D'Udekem* (6). Pl. III. figs. 1–3.

Segments 45–50. Contractile loops usually 4 (4–6). The branchial area somewhat irregular, and apt to be unsymmetrical. Branchiæ rather short, foliate; the posterior margin nearly straight, the anterior curving outward at the middle. A distinct dorsal lip, divided from the alar portions of the area by a deep groove on each side.

This species shows the first trace of the modification which leads to the formation of supplementary branchial processes in the distinct demarcation of the dorsal lip, at the angles of which they are borne by those species which possess them.

4. **Dero Mülleri**, sp. nov. Pl. IV. figs. 9, 10.

Segments 70–95. Contractile loops usually 7 (6–8). The branchial area with separate dorsal lip. Branchial processes oblong, quadrangular, the attached border the longest, superior angles rounded.

The largest of all known species. Furnished to the writer by Mr. Bolton. Chains of two zooids frequently consist of 130–140 segments, and measure nearly an inch in length. Branchial area disproportionately small.

β. With secondary branchiæ.

5. **Dero limosa**, *Leidy* (15). Pl. V. figs. 11–16.

Dero philippinensis, *Semper* (26).

Segments 55–60. Contractile loops 5, the last much the smallest. The branchial area with dorsal lip, each angle bearing a secondary branchia, short, cylindrical, and containing a loop of blood-vessels. Branchial processes as in *D. obtusa*, but longer and narrower.

The foregoing species appears to me, for reasons already stated, to be identical with Prof. Leidy's; and there is no difference which cannot be explained on the grounds laid down (p. 100). Should the species under notice hereafter prove to be distinct from Prof. Leidy's, it will stand as new, unless indeed it be the same as Prof. Semper's *D. philippinensis*, as on the same considerations seems probable; though the latter may possibly be identical with the species next to be described, a point which cannot be settled in the absence of a figure of Prof. Semper's worm.

6. **Dero acuta**, *Bousfield* (5).

Characters nearly as in *D. limosa*; but the branchiæ much longer, obovate in form, with pointed apices; length about 4 or 5 times the greatest breadth.

Only two examples of this species have come under my notice from the localities already mentioned (p. 103). A careful search during the present season has been unsuccessful; so that no figure can be given; but there will be no difficulty in recognizing the worm from the description above.

γ. With secondary branchiæ and palpi.

7. **Dero furcata**, *Oken* (20). Pl. V. figs. 17, 18.

Das geschmeidige Wasserschlänglein mit zwey Gabelspizen, *Rösel* (24).—Dero palpigera, *Grebincky*.—Dero Rodriguezii, *Semper* (26).

Segments 35. The branchial area more funnel-shaped than in the other forms; the dorsal lip not divided off, but bearing supplementary branchiæ at its junction with the alæ. The integumental layer at the tip of the branchial area prolonged into two palpi of varying length, non-ciliated, extra-vascular. Branchiæ nearly cylindrical; contractile loops five. The first dorsal bristle-bundles in the fifth segment.

The most beautiful of all the species of *Dero*; but somewhat anomalous in the position of the first dorsal bristles and in the possession of palpi. Only found among the fibrous bundles of the dead stems of *Cyperus* (in the Royal Botanic Gardens), which must be pulled apart to obtain the worms.

Note.—The above descriptions all apply to the asexual forms only. A description of the sexual forms is reserved.

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DESCRIPTION OF THE PLATES.

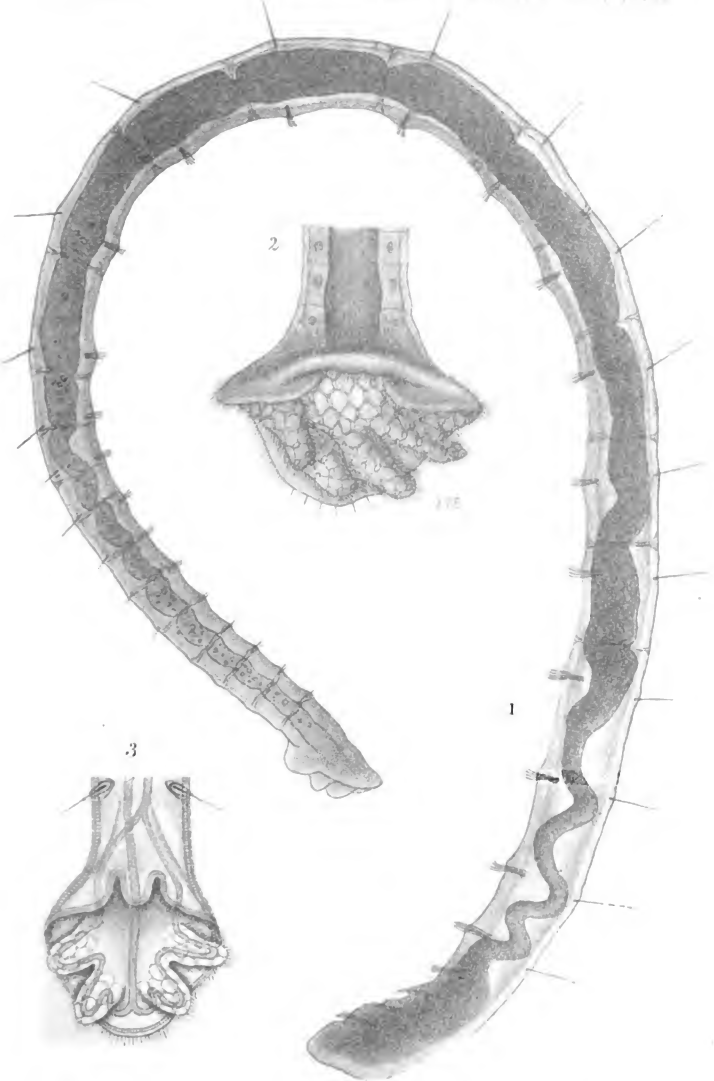
PLATE III.

Fig. 1. *Dero obtusa.* The whole worm, enlarged from a photograph of the living object.

2. A dorsal view of the branchial area and processes of *D. obtusa*, drawn from life. × 75.

3. The same. A copy of D'Udekem's original figure.

E G BOUSFIELDD



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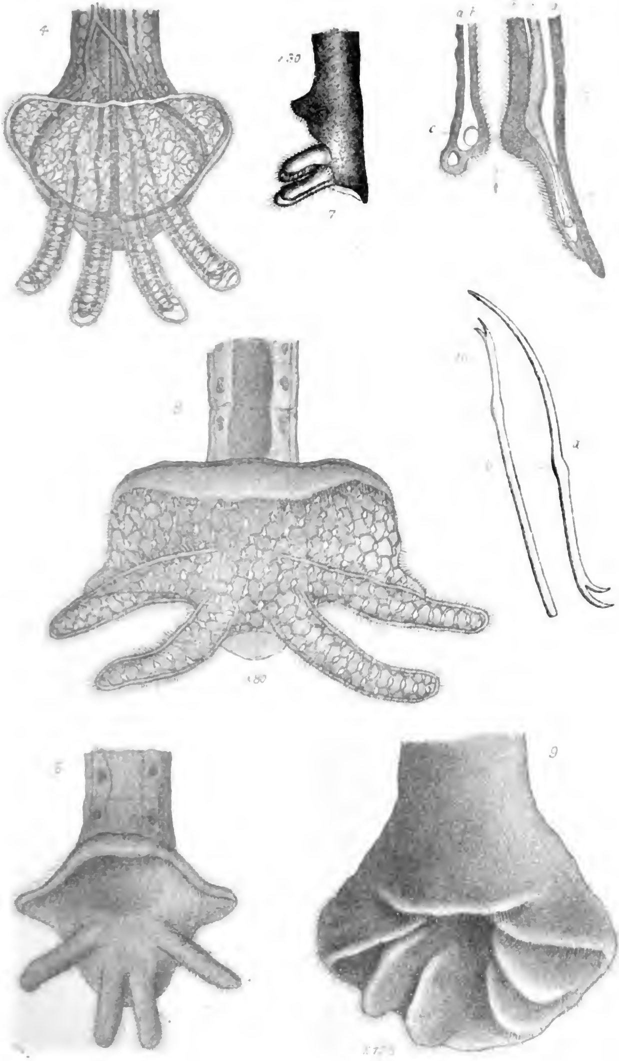
Hanhart imp.

DERO OBTUSA.

E. C. BOUSFIELD

LINN. SOC. JOURN. ZOOL. VOL. XX. PL. 4



4-7. D. PERRIERI. 8. D. [illegible] 9, 10. D. MÜLLERI.

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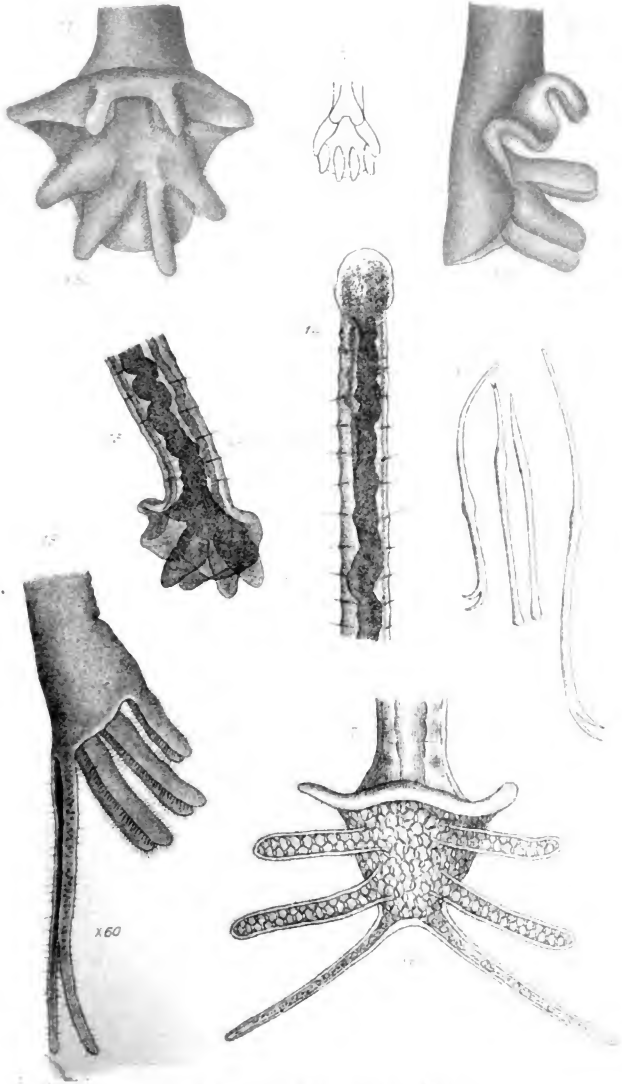

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PLATE IV.

Fig. 4. *Dero Perrieri*, as a transparent object, showing arrangement of blood-vessels &c. After Perrier.
5. The same, in optical longitudinal section: *a*, integumental layer; *b*, ciliated layer; *c*, blood-vessels. From life.
6. The same. Dorsal view of branchial area. From life.
7. The same. Lateral view of branchial area. From life. × 30.
8. *Dero latissima.* Dorsal aspect of branchial area. From life. × 80.
9. *Dero Mülleri.* A similar view. From life. × 125.
10. Setæ of ditto: *a*, ventral seta of second to fifth segments; *b*, hooked dorsal seta of the same segments.

PLATE V.

Fig. 11. *Dero limosa.* Dorsal view of expanded area. From life. × 50.
12. The same. Lateral view of expanded area. From life. × 50.
13. The same. Dorsal view in outline. After Leidy.
14. The same. Ventral view of contracted area. Photographed from life.
15. The same. Ventro-lateral view. Photographed from life.
16. Setæ of *D. limosa*: *a*, ventral seta of second to fifth segments; *b*, ventral seta of sixth and following segments; *c*, hooked dorsal setæ.
17. *Dero furcata.* Dorsal view of branchial area. From life. × 80.
18. The same. Lateral view. From life. × 60.

Notes on a Collection of Crustacea from Singapore.

By ALFRED O. WALKER, F.L.S.

[Read 17th March, 1887.]

(PLATES VI.-IX.)

TOWARDS the end of the year 1879 my friend Mr. F. Archer, of Liverpool, requested me to undertake the naming of a collection of Crustacea which his brother, Surgeon-Major Archer, was then sending over from Singapore. Pressure of other work and want of acquaintance with exotic Crustacea, not to mention the fact of my residing at a distance from London (where alone the necessary works of reference can be procured), caused me to hesitate long before I undertook it; and it was not until it became clear that nobody else in England would undertake the work (such is the scarcity of carcinologists) that I finally decided to do so. I may also add that had it not been for the kind assistance rendered by Mr. E. J. Miers, which gave me the start without which the task would have been almost impossible, I should have given it up at the outset.

Surgeon-Major Archer has furnished me with the following memorandum on the collection, which extended over the years 1879 to 1883 :—

"The species collected were for the most part obtained whilst dredging or searching the reefs in the neighbourhood for Mollusca. The Singapore Strait presents every variety of bottom within a few miles of the town—mud, gravel, sand, rock, and broken ground, may all be met with, each description furnishing its peculiar species. Most of the smaller forms were obtained by means of the dredge at depths seldom exceeding 15 to 20 fathoms. Some of them I extracted from living sponge and interstices of masses of coral. The new harbour, a narrow strait between the islands of Blahan Moti and Ayan Brani on the one side and Singapore Island itself on the other, was the most favourite dredging-ground, as it was conveniently situated and the bottom abounded in animal life. At low water I frequently waded about the reefs and shores of the numerous islands, and obtained many specimens under loose stones and lumps of coral, dead or living.

"The spring tides rise a full ten feet, and between the islands the currents are very strong, at times rendering it difficult for a steam-launch to make way against them. I am not aware what direction ocean currents, if any, take in the Strait.

"A long sandy shore extends to N. of Singapore, from Tanjong Rhoo to Tanjong Katong and other villages; and at spring tides the water recedes a considerable distance, leaving bare extensive banks of sand and mud, where I got a good many forms (amongst them two species with curved hooks on their hindmost claws, by means of which they hold on to a mangrove-leaf or a dead valve of a shell which conceals the animal from view; these leaves and dead valves may be seen apparently walking along on the shore). [These are probably *Dorippe sima* and *D. astuta*, also *Conchæcetes conchifera*.—A. O. W.]

"From the nets of the fishermen on this shore I also got a good many specimens, as likewise from the heaps of small fish, weed, &c., brought by the Chinamen into the market to be sold as food or manure."

The collection is placed in the Public Museum, Liverpool, and duplicates of some of the new species in the Natural History Museum, South Kensington.

Crustacea collected at Singapore by Surgeon-Major S. Archer.

PODOPHTHALMIA.

BRACHYURA.

OXYRHYNCHA.

MAIIDÆ.

Maia Miersii, n. sp. (Plate VI. figs. 1–3.)
Oncinopus neptunus, Adams & White.
Doclea muricata, Herbst.
—— *ovis*, Herbst.
—— *tetraptera*, n. sp. (Plate VI. figs. 4–8.)
Egeria longipes, Herbst.
Hyastenus oryx, A. M.-Edwards.
—— *planasius*, Adams & White.
—— *diacanthus*, De Haan.
Schizophrys aspera, M.-Edwards. (See note, p. 113.)
Micippa mascarenica, Kossman.
—— *curtispina*, Haswell, Proc. Linn. Soc. N. S. W. vol. iv. p. 446, pl. xxv. fig. 1.

PARTHENOPIDÆ.

Gonatonotus pentagonus, Adams & White.
Ceratocarcinus dilatatus, A. M.-Edwards.
Lambrus laciniatus, De Haan.
—— *longispinus*, Miers, Ann. & Mag. Nat. Hist. ser. 5, vol. iv. p. 18).
—— *longimanus*, Leach.
—— *prensor*, Herbst.
Cryptopodia fornicata, Fabr.

CYCLOMETOPA.

CANCRIDÆ.

Atergatis integerrimus, Lamarck.
——*floridus*, Rumph.
Actæa spongiosa, Dana.
—— *areolata*, Dana, var.
—— *Rüppellii*, Krauss; see Miers, in Ann. & Mag. Nat. Hist. ser. 5, vol. v. p. 232.
Xantho scaberrimus, n. sp. (Plate VII. figs. 1–4.)
Lophozozymus epheliticus, Linn.

ERIPHIIDÆ.

Pilumnus vespertilio, Fabr.
—— *De Haanii*, Miers (Proc. Zool. Soc. 1879, p. 32).
—— *labyrinthicus*, Miers (Zool. 'Alert' Collections, p. 224, pl. 22 c).
Actumnus setifer, De Haan.
Eriphia lævimana, Latr., var. *Smithii*, M'Leay; see Miers, in Ann. & Mag. Nat. Hist. ser. 5, vol. v. p. 237.
Trapezia cymodoce, Herbst.
Polycremnus ochtodes, Herbst.

CARCINOPLACIDÆ.

Heteroplax dentatus, Stimpson.

RHIZOPIDÆ.

Typhlocarcinus villosus, Stimpson. (Plate IX. figs. 6–8.)
Ceratoplax ciliatus, Stimpson; 'Challenger' Report, vol. xvii. p. 234, pl. xix. fig. 3.
Galene bispinosus, Herbst.

PORTUNIDÆ.

Neptunus pelagicus, Linn.
Goniosoma natator, Herbst.
—— *crucifera*, Fabr.
—— *inæquale*, n. sp. (Plate VIII. fig. 4.)
Achelous Whitei, A. M.-Edwards.
Thalamita sima, M.-Edwards.
Caphyra Archeri, n. sp. (Plate IX. figs. 4, 5.)

CATOMETOPA.

MACROPHTHALMIDÆ.

Gelasimus vocans, Linn..
Podophthalmus vigil, Fabr.
Ocypoda ceratophthalma, Pallas.

GRAPSIDÆ.

Grapsus strigosus, Latreille.
Pachygrapsus transversus, Gibbes. (See note, p. 113.) Kingsley, Proc. Acad. Nat. Sci. Philadelphia, 1880.
Sesarma Bocourti, A. M.-Edwards. (Plate IX. fig. 9.)

PINNOTHERIDÆ.

Pinnotheres obesus, Dana.
Dotilla myctiroides, M.-Edwards (Mélanges Carcinologiques).

OXYSTOMATA.

LEUCOSIIDÆ.

Leucosia craniolaris, Linn.
—— *Whitei*, Bell.
—— *marmorea*, Bell.
—— *hæmatosticta*, Adams & White.
Myra affinis, Bell.
—— *carinata*, Bell; see Miers, Trans. Linn. Soc. Zool. ser. 2, vol. i. p. 239.
—— *australis*, Haswell, Proc. Linn. Soc. N. S. W. vol. iv. p. 50, pl. v. fig. 3.
Philyra pisum, De Haan.
Nursia plicata, Herbst.
Oreophorus reticulatus, Adams & White.
Tlos muriger, Adams & White.
Arcania 11-*spinosa*, Adams & White (= *A. pulcherrima*, Haswell, *l. c.* p. 58, pl. vi. fig. 4).
Onychomorpha lamelligera, Stimpson. (Plate VIII. fig. 3.)

MATUTIDÆ.

Matuta victrix, Fabr.
—— *lunaris*, Herbst.
—— *Banksii*, Leach.

CALAPPIDÆ.

Calappa lophos (Herbst), var. γ, De Haan.

DORIPPIDÆ.

Dorippe sima, M.-Edwards.
—— *astuta*, Fabr., young.

ANOMURA.

DROMIIDEA.

Dromia vulgaris, M.-Edwards; see Miers, Ann. & Mag. Nat. Hist. ser. 5, vol. v. p. 370.
—— *Rumphii*? Fabr., young.
Conchœcetes conchifera, Haswell.

PORCELLANIDÆ.

Petrolisthes dentata, M.-Edwards; see De Man, Crust. of Mergui Archipelago.

—— *corallicola*, Haswell, var. (Plate VIII. fig. 5.) See note, p. 113.

Polyonyx obesulus, White; see Zool. 'Alert' Collection, p. 372.

—— *cometes*, n. sp. (Plate IX. figs. 1–3.)

Porcellanella picta, Stimpson. (Plate VIII. figs. 1, 2.)

PAGURIDÆ.

Diogenes miles, Fabr.

Clibanarius vulgaris, Herbst.

Cœnobita perlata, M.-Edwards.

Diogenes avarus, Heller. (Plate VIII. figs. 6, 7.) See note, p. 113.

GALATHEIDÆ.

Galathea elegans, Adams & White.

MACRURA.

GEBIIDÆ.

Gebiopsis Darwinii, Miers; see Zool. 'Alert' Collection.

THALASSINIDÆ.

Thalassina anomala, Herbst.

SCYLLARIDÆ.

Thenus orientalis, Herbst.

PALINURIDÆ.

Palinurus ornatus, Fabr.

ALPHEIDÆ.

Alpheus comatularum, Haswell.

—— *minus*, var. *neptunus*, Dana.

—— *Edwardsii*, Audouin.

PALÆMONIDÆ.

Palæmon carcinus, Fabr.

PENÆIDÆ.

Penæus monodon (Fabr.), var. *carinatus*, Dana.

—— *velutinus*, Dana.

—— *affinis*, M.-Edwards.

Acetes indicus, M.-Edwards.

STOMATOPODA.

Squilla nepa, Fabr.
Gonodactylus chiragra, Fabr.

NOTES ON CERTAIN SPECIES.

1. SCHIZOPHRYS ASPERA.—One specimen is the var. *spinifrons* of A. M.-Edwards.

2. PACHYGRAPSUS TRANSVERSUS, Gibbes, appears to be merely a variety of *Metopograpsus messor*.

3. PORCELLANA (? PETROLISTHES) CORALLICOLA, Hasw., var.—The single small specimen differs so much from the typical form in the sculpturing of the wrist and hand of the larger chelipede, that it is a question whether it ought to be referred to this species. The wrist has two rounded longitudinal ridges or carinæ. The upper surface of the hand is divided longitudinally into two unequal parts by a similar ridge, the space on each side of which is covered with tubercles. The fingers have a similar ridge on the outer surface. In the specimen in the British Museum from Queensland the central line of tubercles on the hand shows a tendency to fuse into a carina.

4. DIOGENES AVARUS, Heller, var.—I have some hesitation in referring the single specimen in the collection to this species, with which, however, it agrees except in having the margin of the carapace armed with three small teeth immediately beneath the upper external angle. The hand of the large chelipede is obsoletely costate externally, but is more robust than in Heller's figure, resembling rather in this respect *D. granulatus*, Miers (Ann. & Mag. Nat. Hist. ser. 5, vol. v. p. 373, note). (Plate VIII. figs. 6, 7.)

In addition to the Podophthalmia there were a few Isopoda not yet examined, and a new Amphipod, *Byblis kallarthrus*, Stebbing, described by the Rev. T. R. R. Stebbing, in Proc. Zool. Soc. Jan. 19, 1886.

DESCRIPTION OF NEW SPECIES.

MAIA MIERSII, n. sp. (Plate VI. figs. 1–3.)

Carapax ovalis, granulatus. Margo supraorbitalis spinis 2 longis; margo anterolateralis spinis 5, 2 primis minoribus. (Coll. Brit. Mus.)

Carapace ovoid, rather convex, with scattered hairs, and coarsely granulated. A long spine on the posterior gastric and another on the cardiac region in the central longitudinal line, with a shorter spine at each side of its termination on the posterior border. A long spine on the branchial region. Rostrum with two divergent spines about two sevenths of the length of the carapace and fringed with long hairs; beneath this the edge of the carapace is produced into a tooth bent downwards at a right angle. The basal joint of the outer antennæ is furnished with two spines, the shorter pointing downwards and the longer outwards. The lower orbital margin has a group of four tubercles about the centre. The upper orbital margin has a concave process or hood covering the inner orbital angle, and produced outwards into a long spine; there is a similar and parallel spine at the outer angle, and a small spine between the two. These are followed by five marginal spines, increasing in size to the last, which is equal in length to, and some distance in front of, the spine on the branchial region. The underside is coarsely granulated. The chelipedes in the male are shorter than the second pair of legs, and are slender, rounded, and very smooth. The hand to the base of the fingers is as long as the wrist, and about the same thickness. The fingers slender and without teeth, meeting at a short distance from the point. The remaining legs are moderately long (the second pair reaches slightly beyond the rostrum) and covered with long hairs. Length of carapace, exclusive of rostrum, $1\frac{4}{12}$ in. (=3·3 centim.). Width behind posterior marginal spines, $1\frac{4}{12}$ in.

DOCLEA TETRAPTERA, n. sp. (Plate VI. figs. 4–8.)

Carapax pyriformis tomentosus; spina media posterior magna duplex. Pedes ambulantes alis fimbriatis instructi. (Coll. Brit. Mus.)

Carapace pyriform, having eight spines on the median line, of which the first (a little behind the eye), third, and seventh are very small. The last spine on the posterior margin is very large and double, the smaller branch pointing upwards and the larger backwards. Four spines on the lateral margin, the foremost being close to the outer angle of the buccal orifice, and smaller than the three following. A large spine on the metabranchial, and a smaller on the epibranchial, region. Rostrum horizontal, about one fifth of length of remainder of carapace, with short divergent spines at the tip. The whole of the carapace covered with a dense pubescence, the hairs of which are slightly thickened towards the tip and mucronate (Plate VI. fig. 8). The hand is somewhat compressed, naked, carinate beneath, and finely granulate; the fingers are curved inwards and channelled. Wrist almost orbicular, and, as well as the arm, covered with a fine pubescence and fringed at the edge. The arm has a fringe or "wing" of club-shaped hairs on the upper, and two on the lower, side (Plate VI. fig. 8*). The ambulatory legs have four similar wings on all the joints, which are pubescent, except the extremities of the tarsi, which are deeply channelled. Length of carapace to end of rostrum, $1\frac{11}{16}$ in. (=4·2 centim.). Greatest width, $1\frac{3}{8}$ in. (=3·5 centim.).

XANTHO SCABERRIMUS, n. sp. (Plate VII. figs. 1–4.)

Carapax omnino verrucosus. Chelipedes verrucis magnis, pedes cæteri spinis instructi. (Coll. Brit. Mus.)

Carapace broader than long, moderately convex; regions and subregions strongly defined and covered with large granules, rounded in the central part and becoming more pointed towards the sides. Front 2-lobed. Antero-lateral margin with three prominent teeth, the hindmost being at the beginning of the branchial region, and the foremost (the smallest of the three) about halfway between that and the orbital margin; the central tooth about equidistant from the other two. Postero-lateral margin straight, not concave. Underside also densely granulate. The chelipedes covered with large granules, those on the hand being largest, especially on the outer side, on the lower half of which they are arranged in parallel rows, two of which terminate in carinæ on the fixed finger. The movable finger has a carina on the upper surface, with six granules gradually diminishing from a large one at the base, and two carinæ on the outer side. The walking-legs have a row of spines on the upper edge of the tarsal and carpal joints, with one or two more or less parallel rows below, and the lower edge slightly serrate at the distal extremity. The third and fourth pairs have a deep notch at the distal end of the merus. The fifth pair has a row of large irregular spines along the upper edge of the merus, with two ill-defined rows on the outer side and a row of smaller spines on the lower edge. Colour ashy, shading into dull yellow on the fingers. Length $1\frac{7}{8}$ in. (=4·75 centim.). Breadth $2\frac{7}{16}$ in. (=6·2 centim.).

Goniosoma inæquale, n. sp. (Plate VIII. fig. 4.)

Frons sexdentata. Margo antero-lateralis 7-dentatus, dentibus 2 et 5 minoribus.

Carapace rather convex, very finely granulate, with transverse interrupted beaded lines, one of which crosses the gastric region and has a group of larger granules in front of it and on each side. Front prominent, with six teeth, including orbital angle, the central pair the longest. Upper orbital margin with two small fissures and finely toothed. Antero-lateral margin with seven teeth, the first (the external orbital angle) being the largest, and the second and fifth the smallest; the third has a small accessory tooth at the base of its hinder margin. Chelipedes have the arm finely granulate and furnished with five prominent spines on the anterior border, of which the first is the smallest and the fifth situated some distance from the fourth; on the hind margin one spine at the distal extremity and another a little behind it. Wrist with two spines. Hand with three spines—one springing from the point touched by the overlapping part of the wrist, the other two near to and at equal distances from the base of the movable finger, where there are three tubercles. Fingers long, slender, and strongly carinated. Second pair of legs as long as the first. Merus of last pair of legs having a spine at the distal extremity of the hind margin. Length of carapace $\frac{7}{12}$ in. (=1·3 centim.). Width of carapace $\frac{9}{12}$ in. (=1·9 centim.).

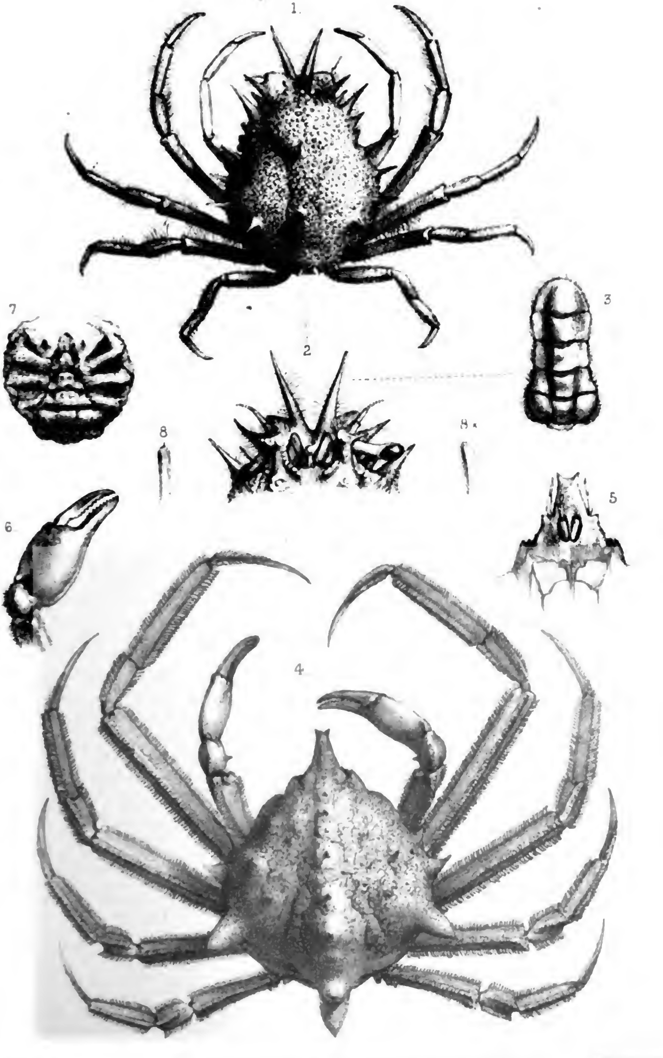
Caphyra Archeri, n. sp. (Plate IX. figs. 4, 5.)

Carapax orbicularis albo-nitens. Frons prominens bilobata, dente magno utrinque instructa.

Carapace almost circular, finely granulate. Front of two semicircular lobes, with a prominent tooth, formed by the anterior orbital angle, behind them; the lobes, teeth, and antero-lateral margin of the carapace finely denticulate. Chelipede (the right wanting in the single specimen) large; the hand about three fourths the diameter of the carapace, widening slightly towards the base of the fingers, and granulate, more coarsely on the underside. Remaining legs short and robust, the last joint short and curved. Length (including front) $2\frac{1}{4}$ lines (=4·75 millim.). Width 2 lines (=4 millim.).

Polyonyx cometes, n. sp. (Plate IX. figs. 1–3.)

Carapax transverse ovatus. Chelipedes magni supra crinibus longis instructi; subtus albi, nitentes. (Coll. Brit. Mus.)



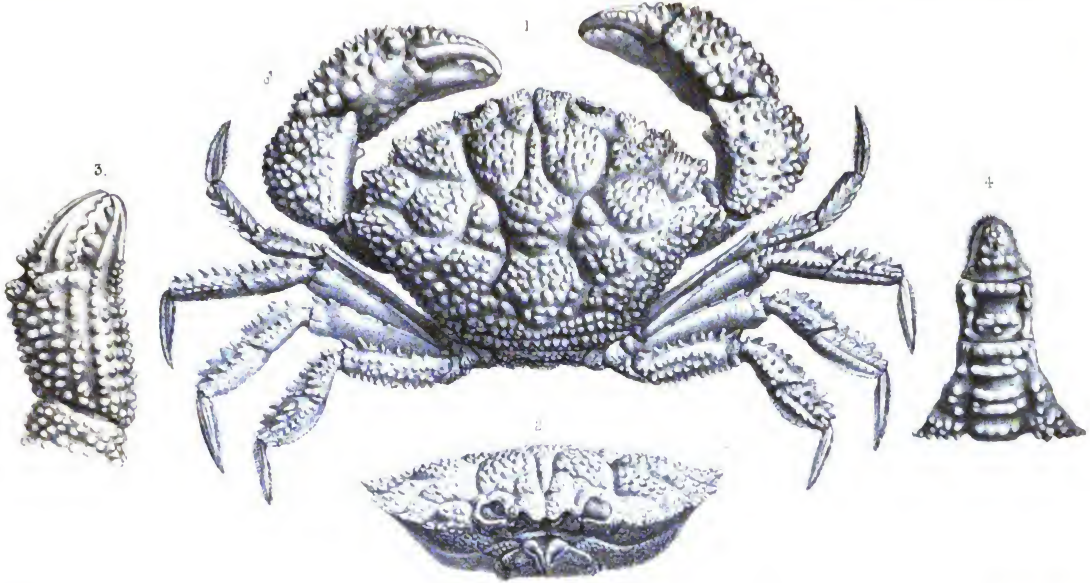
Michael lith

1-3, MAIA MIERSI, ♂. 4-8x DOCLEA TETRAPTERA

Mintern imp.

A. O. Walker

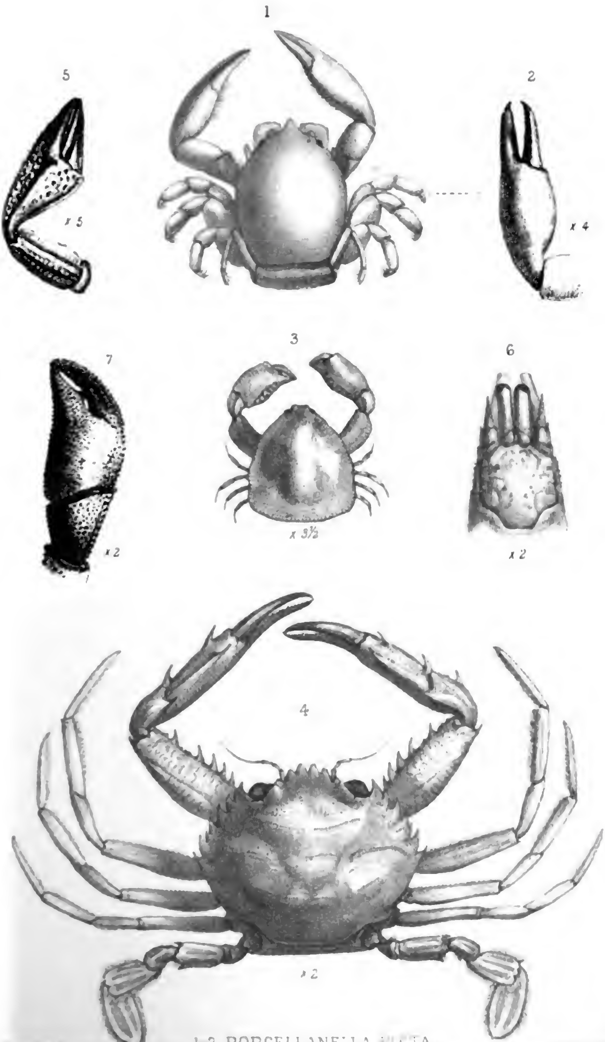
LINN. SOC. JOURN. ZOOL. VOL. XX. PL. 7



Crowther lith.

XANTHO SCABERRIMUS, ♂.

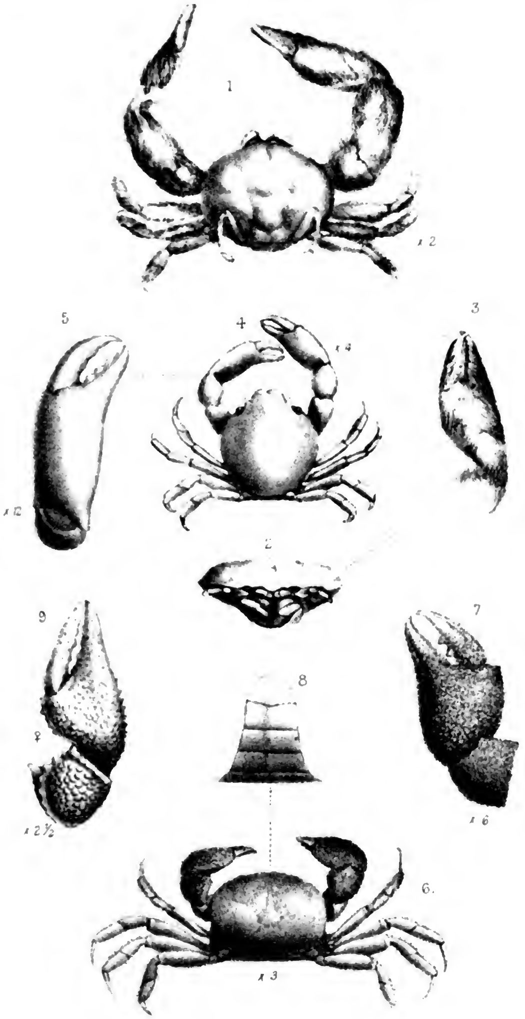
Mintern imp.



Michael lith. Mintern imp.

1-2, PORCELLANELLA PICTA.
3, ONYCHOMORPHA LAMELLIGERA 4, GONIOSOMA INÆQUALE
5, PETROLISTHES CORALLICOLA VAR 6-7, DIOGENES AVARUS

A C Walker



1-3, POLYONYX COMETES. 4-5, CAPHYRA ARCHERI.

Crowther lith.

Mintern imp.

6-8, TYPHLOCARCINUS VILLOSUS. 9, SESARMA BOCOURTI, ♀

Carapace transversely ovate, very slightly convex, smooth, and shining; regions strongly defined, especially behind; edge fringed with long hairs. Front slightly prominent in the middle. Chelipedes very large, equal, densely covered on the upperside with long hairs, smooth and shining white on the underside; wrist shorter than the hand and hollowed out on the inner side. Next three pairs of legs short and weak, covered with long hair on the upperside; dactylus very small and curved; merus strong, as long as the two following joints. Last pair of legs long, slender, and almost naked; the last joint polished and horn-coloured, with a brush of hairs at the extremity. Length $\frac{4}{12}$ in. (=8 millim.). Width $\frac{5}{12}$ in. (=10 millim.).

DESCRIPTION OF THE PLATES.

PLATE VI.

Fig. 1. *Maia Miersi*, ♂.
2. Ditto, underside of orbital region.
3. Ditto, abdomen.
4. *Doclea tetraptera*, ♂.
5. Ditto, underside of orbital region.
6. Ditto, left chelipede.
7. Ditto, abdomen.
8, 8*. Ditto, hairs (magnified).

PLATE VII.

Xantho scaberrimus, ♂.

PLATE VIII.

Fig. 1. *Porcellanella picta*.
2. Ditto, left chelipede.
3. *Onychomorpha lamelligera*.
4. *Goniosoma inæquale*.
5. *Petrolisthes corallicola*, var., chelipede.
6. *Diogenes avarus*, cephalothorax.
7. Ditto, chelipede.

PLATE IX.

Fig. 1. *Polyonyx cometes*.
2. Front view of ditto.
3. Right chelipede of ditto.
4. *Caphyra Archeri*.
5. Chelipede of ditto.
6. *Typhlocarcinus villosus*.
7. Left chelipede of ditto.
8. Abdomen of ditto, ♂.
9. *Sesarma Bocourti*, chelipede of ♀.

Observations on Ants, Bees, and Wasps.—Part XI.

By Sir John Lubbock, Bart., M.P., D.C.L., LL.D., F.R.S.

[Read 1st December, 1887.]

On the Relation between *Formica sanguinea* and its Slaves.

It is well known that *Polyergus rufescens* is entirely dependent on its slaves. Huber long ago found that this ant will starve in the midst of plenty, and will not even put food into its own mouth. I have shown that isolated specimens will live for months if they are allowed a slave for an hour or so every two or three days to clean and feed them. It is said, on the contrary, that our only slave-making species, *Formica sanguinea*, can manage without slaves. Indeed, it appears that nests are sometimes found in which there are mistresses alone, entirely without slaves. Forel thinks that he has observed in such nests generally a larger proportion of small individuals than in nests which possess slaves. This would be interesting as tending to show that in such nests the young are less well nourished than when they have slaves to attend upon them.

The question remains, of what advantage are the slaves to the *F. sanguinea*? Forel says, I do not quite understand why, "Je ne veux pas trop rechercher le motif qui pousse les *sanguinea* a se faire presque toujours des esclaves." "Peut-être," he adds, "le sentiment de leur force, et le désir de travailler moins, pour faire plus à leur aise la chasse aux *Lasius flavus* et *L. niger*, est-il le mobile qui les pousse à cet acte. Celui-ci leur serait peu à peu devenu plus ou moins instinctif puisqu'il était avantageux à la conservation de leur espèce." This suggestion seems very probable, and may be partially correct; it is not, however, I think, a complete explanation. I have had under observation several nests of *F. sanguinea*. One of them I owe to the kindness of M. Forel himself, who sent it to me in June 1882. There was no queen, and, though the nest was very healthy, of course the numbers gradually diminished. At the beginning of January 1886 the last slave died, and there then remained only about 50 *F. sanguinea*. Under these circumstances the *F. sanguinea* began to die off rapidly; by the middle of the year only six remained alive, and these, no doubt, would not have survived long. On July 1st I got some pupæ of *F. fusca* and placed them outside the nest. The *sanguineas* soon discovered them, carried them into the nest, and from that day until December 1887, more than six months, there was only one other death. [Two of the *F. sanguinea* are still (August 1888) alive.] Although then it may be true, as to which I express no opinion, that there are nests of *F. sanguinea* without slaves, still this observation seems to indicate that the slaves perform some important function in the economy of the nest. It still remains to be determined in what exactly this function consists.

ANT-GUESTS.

Dr. Wasmann has recently published * an interesting memoir on certain of these "Ant-guests." His observations relate exclusively to some of the beetles which live with ants.

He confirms V. Hagen's statement that the specimens of *Atemeles emarginatus* which live with *Myrmica lævinodis*, a yellow ant, are paler in colour than those which share the nests of the black *Formica fusca*. He entirely confirms the statements of previous observers that the *Atemeles* is actually fed by the ants, who also clean them just as they do their own fellows. The *Atemeles* also, on their part, perform the same kind offices for the ants. He also repeatedly saw the ants licking the bunches of golden hairs on the abdomen of the *Atemeles*.

The *Atemeles* has adopted very closely the habits of the ants with which it lives. They pair, moreover, in the nests of the ants. Still, they are not entirely dependent on their hosts, like some of the other ant-guests, but are able to feed themselves. Indeed the *Myrmicas* seem to drive them out of the nest towards the beginning of May. Dr. Wasmann is disposed to attribute this to the anxiety of the ants for their young. In *Myrmica* the pupæ are naked, and he thinks the ants are afraid that the *Atemeles* would be unable to resist the temptation of eating them. In support of this suggestion, he observes that in the nests of *Formica sanguinea*, whose pupæ spin a silken cocoon and are therefore protected, he has found *Atemeles* as late as the end of June. He has not been able to satisfy himself whether the larvæ of *Atemeles* are brought up in the ants' nest or not; but inasmuch as while the *Atemeles* are far from rare, he has only found among them a single larva which could belong to the species, and even this was not certainly identified, it seems probable that the larval stage is passed elsewhere.

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* Deutsche Entom. Zeitschrift, 1886, p. 49.

Lomechusa strumosa has been recorded from the nests of *Formica sanguinea, Myrmica rubra, Formica congerens,* and *F. rufa*; but Dr. Wasmann, like V. Hagen and Forel, has never found it except with *F. sanguinea.* It is fed by the ants in the same manner as *Atemeles,* and has very similar bundles of golden hairs on the abdomen, which are licked by the ants like those of *Atemeles.* While, however, the ants seem to communicate with the *Atemeles* mainly by means of the antennæ, in the case of *Lomechusa* the parts of the mouth are brought more into play. He has found *Lomechusa* in the ants' nests up to the end of June.

Dinarda dentata is a still more frequent inmate in the nests of *F. sanguinea,* but plays a very different part. The ants seem indifferent to them, and when they take any notice it is of an unfriendly character. Nor can this be wondered at, for according to M. Wasmann the principal food of the *Dinardas* consists of any ant which may chance to die, or any other weak insect which falls in their way. The ants seem thoroughly to distrust them, and it is curious that they should be tolerated. Grimm, indeed, thought he had seen ants licking the *Dinardas,* as they do *Atemeles* and *Lomechusa.* Wasmann, however, considers that this was a mistake; at any rate he has never seen anything of the kind. If an ant meets a *Dinarda* she either treats it with indifference or threatens the beetle with her jaws, and the *Dinarda* then raises its abdomen, which appears always to drive away the ant. It is possible that the *Dinarda* has the power of producing an odour distressing to the ants, or perhaps they eject poison like the *Formicas* themselves. They seem always to remain in the nests of the ants, and pass through their transformation in them. *Formica sanguinea,* like *F. rufa* and *F. congerens,* changes its nest periodically twice a year; such, at least, is said to be the case on the continent; I am not aware whether the same habit has been observed in this country. The summer nests are looser and opener, the winter ones lower and more compressed. In their migration from one nest to the other, which are occasionally at some distance apart, the ants are accompanied by the *Dinardas.* On one occasion, when the ants were flitting, Dr. Wasmann in 20 minutes captured among them thirteen specimens of *Dinarda*; while under other circumstances he never saw one outside the nest.

Hetærius ferrugineus, belonging to a totally different family of beetles, the Histeridæ, and which inhabits the nests of *Polyergus* *rufescens*, *Formica sanguinea*, *F. pressilabris*, *F. fusca*, *F. rufibarbis*, *F. rufa*, *F. exsecta*, *Lasius niger*, and *Tapinoma erraticum*, appears to agree in its habits with *Dinarda*, and to devour dead and wounded ants, as also do the Myrmedoniæ.

Dr. Wasmann confirms entirely my observations, in opposition to the statements of Lespès, that while ants are deadly enemies to those of other nests, even of the same species, the domestic animals, on the contrary, may be transferred from one nest to another and are not attacked.

He justly observes that, no doubt, many interesting discoveries are in store for us as to the relations between ants and their guests. The marvellous and grotesque antennæ of the Paussidæ will doubtless, one of these days, tell a wonderful story to some patient and fortunate observer.

MIMICRY AMONG ANTS.

Prof. C. Emery has published in the Bull. della Soc. Ent. Italiana, 1886, a short, but interesting note on the habits of *Camponotus lateralis*. Of this species there are two varieties: one black, like its nearest allies; the other red, with the abdomen and part of the thorax black. They live in small colonies, and make expeditions up trees to collect honey-dew from the Aphides. The black type (*C. foveolatus*, Mayr, *C. ebeninus*, Emery) sometimes goes in troops, but generally a few join the troops of other black ants, such as *Formica gagates* and *Camponotus æthiops*. Prof. Emery suggests that, their numbers being small and their sight not very good, they find it convenient to accompany other ants which live in larger communities, and that they perhaps escape detection from the similarity of colour.

This suggestion derives some support from the fact that the red variety accompanies in a similar manner the troops of *Cremastogaster scutellaris*, which is red and black, and at first sight curiously like the red variety of *C. lateralis*. *Cremastogaster scutellaris* lives in immense communities among the pine woods along the shores of the Mediterranean, and is, as I know to my cost, a very pugnacious species. Prof. Emery suggests that the black form of *C. lateralis* is the original type, resembling as it does its nearest congeners; and that the red variety has the advantage, from its similarity to *Cremastogaster scutellaris*, of using that species as its guide and of sharing, undetected, in the produce of its flocks and herds. Prof. Emery observes that he only suggests this explanation. The facts he mentions are very interesting, and it is to be hoped that he will continue his observations.

ON THE COLOUR-SENSE OF ANTS.

Prof. Graber* has published an interesting memoir on this subject. He confirms my observations on ants and Daphnias, in which I showed that they are sensitive to the ultra-violet rays, by similar observations on earthworms, newts, &c. It is interesting, moreover, that the species examined by him showed themselves, like the ants, especially sensitive to the blue, violet, and ultra-violet rays. Prof. Graber, however, states that he differs from me, inasmuch as I attributed the sensitiveness to the ultra-violet rays exclusively to vision; that it is "ausschliesslich durch die Augen vermittelt." I would not, however, express that opinion as applying absolutely to all animals, though it is, I believe, true of ants, where the opacity of the chitine renders it unlikely that the light would be perceived except by the medium of the eyes and ocelli.

Graber has demonstrated in earthworms and newts, and Plateau in certain Myriapods†, that these animals perceive the difference between light and darkness by the general surface of the skin. But more than this, Graber appears to have demonstrated that earthworms and newts distinguish not only between light of different intensities, but also between rays of different wave-lengths, preferring red to blue or green and green to blue. He found, moreover, as I did, that they are sensitive to the ultra-violet rays. Earthworms, of course, have no eyes, but thinking that the light might perhaps act directly on the cephalic ganglia, Graber decapitated a certain number, and found that the light still acted on them in the same manner, though the differences were not so marked. He also covered over the eyes of newts, and found that the same held good with them. Hence he concludes that the general surface of the skin is sensitive to light.

These results are certainly curious and interesting; but, even if we admit the absolute correctness of his deductions, I do not see that they are in opposition to those at which I had arrived. My main conclusions were that ants, Daphnias,

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* "Fundamental Versuche über die Helligkeits- und Farben Empfindlichkeit augenloser und geblendeter Thiere," Sitz. Kais. Akad. der Wiss. Wien, 1883.

† Journ. de l'Anatomie et de la Physiologie, 1886, p. 431.

&c., were able to perceive light of different wave-lengths, and that their eyes were sensitive to the ultra-violet rays much beyond our limits of vision. His observations do not in any way controvert these deductions: indeed the argument by which (p. 234) he endeavours to prove that the effect is due to true light and not to warmth, presupposes that sensations which can be felt by the general surface of the skin are still more vividly perceived by the special organs of vision.

Prof. Graber's observations have been followed up by M. Forel *. He took fifteen specimens of *Camponotus ligniperdus*, which is a large species and, moreover, possesses the advantage, for this purpose, of having no ocelli, and carefully covered the eyes with opaque varnish. He then placed them in a box with ten normal specimens of the same species (to which he subsequently added five more), and covered over one half of the box with cardboard and the other half with a layer of water. In this way the one half of the box was darker than the other, but the temperature of the two sides was approximately equal. In four experiments the numbers were as follows:—

Under the cardboard.		Under the water.	
Hoodwinked Ants.	Normal Ants.	Hoodwinked Ants.	Normal Ants.
3	9	12	1
13	7	3	3
9	9	5	1
3	8	12	2
—	—	—	—
28	33	32	7

It will be seen that a very large majority of the normal ants in every case went under the cardboard; while it was practically indifferent to the hoodwinked ants in which side of the box they rested. Moreover, every time the water and the cardboard were transposed, the normal ants were much excited and began running about to avoid the light, while the hoodwinked ants were quite unaffected.

These experiences therefore proved that the varnish did, in fact, render the ants temporarily blind, their instincts being in other respects unaffected.

He then replaced the cardboard and water by a solution of esculine, which is impervious to the ultra-violet rays, and a glass of deep cobalt, which stopped most of the other rays but permitted the ultra-violet to pass. The results then were :—

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* Rec. Zool. Suisse, 1887.

Under the Esculine.		Under the Cobalt glass.	
Hoodwinked Ants.	Normal Ants.	Hoodwinked Ants.	Normal Ants.
11	8	3	1
11	13	4	2
9	12	5	3
5	13	9	2
10	12	4	3
3	11	12	3
12	13	3	1
—	—	—	—
61	82	40	15

Thus, then, a very large proportion of the normal ants preferred to avoid the ultra-violet rays by going under the esculine. To the varnished ants, on the contrary, it was indifferent whether they were under the esculine or the cobalt. The slight preponderance in favour of the esculine was probably partly due to having started the experiments with a larger number of ants in the side of the box then covered with esculine, and partly from the fact that the hoodwinked ants would have a tendency to accompany the others.

From these and other experiments M. Forel comes to the same conclusion as I did, that the ants perceive the ultra-violet rays with their eyes; and not, as suggested by Graber, by the skin generally.

Experiments with *Platyarthrus*.

In connection with this subject I may add that I do not at all doubt the sensitiveness to light of eyeless animals. In experimenting on this subject I have always found that though the *Platyarthrus*, which live with the ants, have no eyes, yet if part of the nest be uncovered and part kept dark, they soon find their way into the shaded part. It is, however, easy to imagine that in unpigmented animals, whose skins are more or less semitransparent, the light might act directly on the nervous system, even though it could not produce anything which could be called vision.

ON THE FUNCTION OF THE COMPOUND EYES AND OCELLI.

Forel agrees with Réaumur, Marcel de Serres, and Dugès, that in insects which possess both ocelli and compound eyes the ocelli may be covered over without materially affecting the movements of the animals; while, on the contrary, if the compound eyes are so treated, they behave just as in the dark. For instance Forel varnished over the compound eyes of some flies (*Calliphoria vomitoria* and *Lucilia cæsar*), and found that if placed on the ground they made no attempt to rise, while if thrown in the air they flew first in one direction and then in another, striking against any object that came in their way, and being apparently quite unable to guide themselves. They flew repeatedly against a wall, falling to the ground and unable to alight against it as they do so cleverly when they have their eyes to guide them. Finally, they ended in flying away straight up into the air and quite out of sight.

Johannes Müller inclined to the opinion that insects saw near objects with their ocelli. Plateau satisfied himself that the movements of insects are not affected by the ocelli being covered over, and hence concluded that they are rudimentary organs. The complexity of their structure, however, seems fatal to this conclusion.

Forel confesses that the use of the ocelli still remains an enigma, but he is disposed to think that they enable their possessors to see in comparative darkness. He observes[*] that they are specially developed in insects which require to see both in bright light and also in comparative obscurity. Aerial insects do not generally require or possess ocelli.

Lebert expresses the opinion[†] that in spiders some of their eight eyes—those which are most convex and brightly coloured—serve to see during daylight; the others, flatter and colourless, during the dusk. Pavesi has observed[‡] that, while the species of *Nesticus* possess normally eight eyes, in a cave-dwelling species (*Nesticus speluncarum*) there are four only, the four middle eyes being atrophied. This suggests that the four central eyes serve specially in daylight.

SENSE OF SMELL.

In my previous memoirs I have recorded a few experiments which convinced me that ants are gifted with a very highly developed sense of smell, and that this resides in the antennæ.

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[*] *L. c.* p. 181.

[†] Die Spinnen der Schweiz, p. 6.

[‡] "Sopra una nuova specie di Ragni appartenente alle collezioni del Museo Civico di Genova," Ann. Mus. Civ. 1873, p. 344.

Forel, Graber, Lefebvre, Perris, and other recent writers have come to the same conclusion, and there can, I think, be no reasonable doubt that in very many insects the antennæ serve as organs of smell. At the same time it does not necessarily follow that the sense of smell should be confined to them. Even in ourselves it is not always easy to distinguish the sense of taste from that of smell.

Graber deprived a beetle (*Silpha thoracica*) of its antennæ, and then tested it with oil of rosemary and asafœtida. A beetle of the same species, but with antennæ, showed its perception by movement in half a second to one second in the case of the oil of rosemary, and rather longer, 1 second to 2 seconds, in the case of the asafœtida. The *Silpha* without antennæ showed its perception of the oil of rosemary in 3 seconds on an average of eleven times, while in no case did it show any indication of perceiving the asafœtida even in 60 seconds.

Prof. Graber infers, "dass der eine Geruchsstoff (Assa-fœt), der nichts weniger als ein sehr feiner ist, nur durch das Medium der Fühler perzipiert Bewegungen auslöst, während der andere (Rosmarinöl) ähnliches auch ohne Vermittlung dieser angeblich spezifischen Geruchsorgane bewirkt."

Graber questions some of the experiments which seemed to me to demonstrate the existence of a sense of smell in ants. He says:—

"Da Lubbock noch hinzufügt, dass keiner, der das Benehmen der Ameisen unter diesen Umständen beobachten würde, den geringsten Zweifel an ihrem Geruchsvermögen haben könnte, wählte ich auch diese Methode, um zu erforschen, wie sich etwa der Fühler beraubte Ameisen verhalten, würden. Ich war nicht wenig überrascht zu finden, dass auch diese (es handelt sich um *Formica rufa*) vor dem Riechobjekt umkehrten. Um ganz sicher zu gehen, versuchte ich's aber noch mit dem gleichen Arrangement aber *mit Weglassung des Riech*-stoffes, und siehe da! sie kehrten auch jetzt noch um! Bei genauerer Beobachtung der von einer Ameise vom Anfang an auf dem Papiersteg zurückgelegten Strecke stellte sich auch bald heraus, dass es sich bei dem gewissen Umkehren lediglich um ein versuchsweises Abschreiten oder Ausprobiren des unbekannten Weges handelt, oder dass sich die Ameisen ähnlich benehmen wie wir selbst, wenn wir etwa auf einem schwanken Brette eine tiefe Gebirgskluft überschreiten sollen."*

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* V. Graber, "Vergl. Grundversuche über die Wirk. und d. Aufnahmestellen chem. Reize bei den Thieren." Biol. Centralblatt. vol. xiii. p. 449 (1885–6).

M. Graber's observation is, I doubt not, quite correct, but his inference is not well founded, nor was his experiment the same as mine. It is quite true that if an ant be started off along a narrow paper bridge, she will after awhile turn round and come back again. I do not, however, think that this is due, as he suggests, to any sense of giddiness. Ants which habitually climb trees are not likely to be affected by any such sensation. It is rather, I believe, that they feel they are being sent on a fool's errand. Why should they start off and run straight forward into a strange country? They turn round in hopes of finding their way home, whether the bridge is high or low, broad or narrow, or indeed whether they are on any bridge at all. M. Graber has not observed that I expressly stated that in each case they stopped exactly when they came to the scented pencil.

SENSE OF DIRECTION.

Fabre has made a number of experiments from which he concludes that bees have a certain sense of direction. My own experiments led me to the opposite opinion. I have now repeated some of them, and made others, which all led to the same conclusion. For instance I put down some honey on a piece of glass, close to a nest of *Lasius niger*, and when the ants were feeding I placed it quietly on the middle of a board 1 ft. square and 18 inches from the nest. I did this with 13 ants and marked the points at which they left the board. Five of them did so on the half of the board nearest to the nest, and 8 on that turned away from it; I then timed 3 of them. They all found the nest eventually, but it took them 10, 12, and 20 minutes respectively. Again, I took 40 ants which were feeding on some honey, and put them down on a gravel-path about 50 yards from the nest, and in the middle of a square 18 inches in diameter, which I marked out on the path by straws. They wandered about with every appearance of having lost themselves, and crossed the boundary in all directions. I marked down where they left the square and then took them near the nest, which they joyfully entered. Two of them, however, we watched for an hour. They meandered about, and at the end of the time one was about 2 feet from where she started, but scarcely any nearer home; the other about 6 feet away, and nearly as much further from home.

I prepared a corresponding square on paper, and having indicated by the arrow the direction of the nest, I marked down the spot where each ant passed the boundary. They crossed it in all directions; and if the square were divided into two halves, one towards the nest and one away from it, the number in each was almost exactly the same.

Recognition of Friends.

In the interesting memoir already cited Forel says:—"Lubbock (*l. c.*) a cru démontrer que les fourmis enlevées de leur nid à l'état de nymphe et écloses hors de chez elles étaient néanmoins reconnues par leurs compagnes lorsqu'on les leur rendait. Dans mes *Fourmis de la Suisse*, j'avais cru démontrer le contraire. Voici une expérience que j'ai faite ces jours-ci: le 7 août, je donne des nymphes de *Formica pratensis* près d'éclore à quelques *Formica sanguinea* dans une boîte. Le 9 août quelquesunes éclosent. Le 11 août, au matin, je prends l'une des jeunes *pratensis* âgée de deux ou trois jours seulement et je la porte à la fourmilière natale dont elle était sortie comme nymphe seulement 4 jours auparavant. Elle y est fort mal reçue. Ses nourrices d'il y a 4 jours l'empoignent qui par la tête, qui par le thorax; qui par les pattes en recourbant leur abdomen d'un air menaçant. Deux d'entre elles la tirent longtemps en sens inverse chacune par une patte en l'écartelant. Enfin cependant on finit par la tolérer, comme on le fait aussi pour de si jeunes fourmis (encore blanc jaunâtre) provenant de fourmilières différentes. J'attends encore deux jours pour laisser durcir un peu mes nouvelles écloses. Puis j'en reporte deux sur leur nid. Elles sont violemment attaquées. L'une d'elles est inondée de venin, tiraillée et tuée. L'autre est longtemps tiraillée et mordue, mais finalement laissée tranquille (tolérée?). On m'objectera l'odeur des *sanguinea* qui avait vécu 4 jours avec la première et 6 jours avec les deux dernières. À cela je répondrai simplement par l'expérience de la page 278 à 282 de mes *Fourmis de la Suisse*, où des *F. pratensis* adultes séparées depuis deux mois de leurs compagnes par une alliance forcée avec des *F. sanguinea*, alliance que j'avais provoquée, reconnurent immédiatement leurs anciennes compagnes et s'allièrent presque sans dispute avec elles. Je maintiens donc mon opinion: les fourmis apprennent à se connaître petit à petit à partir de leur éclosion. Je crois du reste que c'est au moyen de perceptions olfactives de contact."*

I have, however, repeated my previous observations with the same results.

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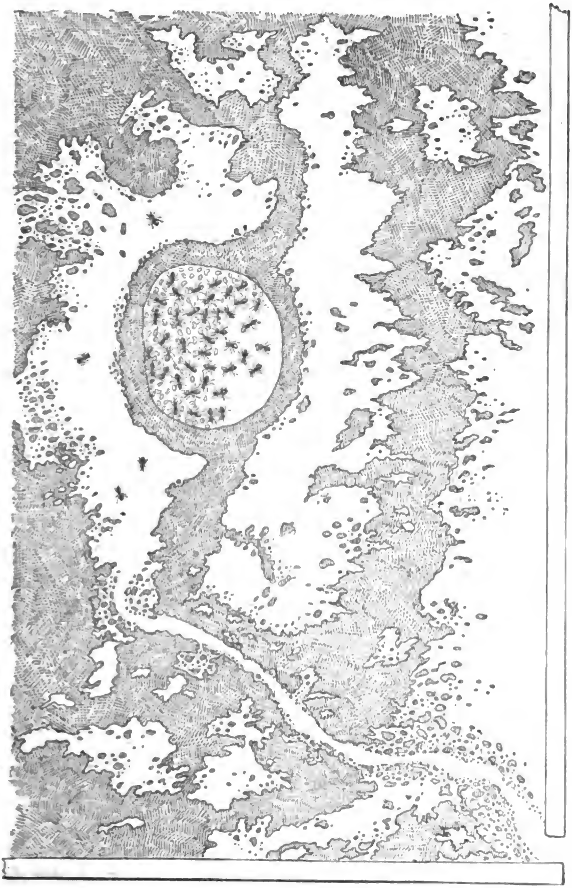
* August Forel, "Expérience et Remarques critiques sur les Sensations des Insectes." Recueil Zool. Suisse, tome iv. (1887), pp. 179–180.



Part of one of my Ant-cases, showing circular nest of *Tapinoma*, with pathway leading to the opening. The Ants enter the circular fortification by one or two tunnels not visible in the figure.

At the beginning of August I brought in a nest of *Lasius niger* containing a large number of pupæ. Some of these I placed by themselves in charge of three ants belonging to the same species, and taken from a nest which I have had under observation for rather more than 10 years. On the 28th August, I took 12 of the young ants, which in the meantime had emerged from the separated pupæ, selecting some which had all but acquired their full colour. Four of them I replaced in their old nest, and four in that from which their nurses were taken.

At 4.30. In their own nest none were attacked.
In their nurses' nest one was attacked.
5. In their own nest none were attacked.
In their nurses' nest all four were attacked.
8. In their own nest none were attacked.
In their nurses' nest three were attacked.

The next day I took six more and marked them with a spot of paint as usual, and at 7.30 replaced them in their own nest.

At 8 I found 5 quite at home. The others I could not see, but none were attacked.
8.30 ,, 5 ,, ,, ,,
9 ,, 3 ,, ,, ,,
10 ,, 4 ,, ,, ,,
11 ,, 5 ,, ,, ,,
12 ,, 3 ,, ,, ,,
1 ,, 3 ,, ,, ,,
4 ,, 4 ,, ,, ,,
7 ,, 1 ,, ,, ,,
9 ,, 2 ,, ,, ,,

The next morning I could only see two, but none were being attacked and there were no dead ones. It is probable that the paint had been cleaned off the others, but it was not easy to find them all among so many. At any rate none were being attacked nor had any been killed.

These observations, therefore, quite confirm those previously made, and seem to show that if pupæ are taken from a nest, kept till they become perfect insects, and then replaced in the nest, they are recognized as friends.

When we consider the immense number of ants in a nest, amounting in some cases to over 500,000, it is a most remarkable fact that they all know one another. If a stranger, even belonging to the same species, be placed among them, she will be at once attacked and driven out of the nest. Nay, more, I have already shown that they remember their friends even after more than a year's separation, and that it is not by any sign or password, because even if rendered intoxicated, so as to be utterly insensible, they are still recognized. As regards the mode of recognition, Mr. McCook considers that it is by scent, and states that if ants are more or less soaked in water, they are no longer recognized by their friends, but are attacked. He mentions a case in which an ant fell accidentally into some water:—

"She remained in the liquid some moments and crept out of it. Immediately she was seized in a hostile manner, first by one, then by another, then by a third; the two antennæ and one leg were thus held. A fourth one assaulted the middle thorax and petiole; the poor little bather was thus dragged helplessly to and fro for a long time, and was evidently ordained to death. Presently I took up the struggling heap. Two of the assailants kept their hold; one finally dropped, the other I could not tear loose, and so put the pair back upon the tree, leaving the doomed immersionist to her hard fate."

His attention having been called to this, he noticed several other cases, always with the same result. I have not myself been able to repeat the observation with the same species, but with two at least of our native ants the results were exactly reversed. In one case five specimens of *Lasius niger* fell into water and remained immersed for three hours. I then took them out and put them into a bottle to recover themselves. The following morning I allowed them to return. They were received as friends, and though we watched them from 7.30 till 1.30 every hour, there was not the slightest sign of hostility. The nest was moreover placed in a close box, so that if any ant were killed we could inevitably find the body, and I can therefore positively state that no ant died. In this case, therefore, it is clear that the immersion did not prevent them from being recognized. Again, three specimens of *Formica fusca* dropped into water. After three hours I took them out, and after keeping them by themselves for the night to recover, I put them back into the nest. They were unquestionably received as friends, without the slightest sign of hostility, or even of doubt. I do not, however, by any means intend to express the opinion that smell is not the mode by which recognition is effected.

LONGEVITY.

It may be remembered that my nests have enabled me to keep ants under observation for long periods, and that I have identified workers of *Lasius niger* and *Formica fusca* which were at least 7 years old, and two queens of *Formica fusca* which have lived with me ever since December 1874. One of these queens, after ailing for some days, died on the 30th July, 1887. She must then have been more than 13 years old. I was at first afraid that the other one might be affected by the death of her companion. She lived, however, until the 8th August, 1888, when she must have been nearly 15 years old, and is therefore by far the oldest insect on record.

Moreover, what is very extraordinary, she continued to lay fertile eggs. This remarkable fact is most interesting from a physiological point of view. Fertilization took place in 1874 at the latest. There has been no male in the nest since then, and, moreover, it is I believe well established that queen ants and queen bees are fertilized once for all. Hence the spermatozoa of 1874 must have retained their life and energy for 13 years, a fact, I believe, unparalleled in physiology.

In some plants (Rues) the pollen-tube takes as long as two years to reach the ovule. Indeed the pollen has some claims to be regarded as a separate organism, for it certainly possesses the power of growth and of assimilating nourishment. There is not, however, so far as I am aware, any other case which can compare with that of my queen ant as regards the longevity of the male element. One is even tempted to wonder, under such circumstances, whether there is any multiplication of the spermatogenic cells.

Moreover the case is not altogether isolated. I had another queen of *Formica fusca* which lived to be 13 years old, and I have now a queen of *Lasius niger* which is more than 9 years old, and still lays fertile eggs which produce female ants.

ANTS AND SEEDS OF *Melampyrum pratense*.

M. Lündstrom has recently called attention to the interesting fact that the seeds of this plant closely resemble pupæ of ants in size, shape, and colour, even to the black mark at one end. He has suggested very ingeniously that this may be an advantage to the plant by deceiving the ants, and thus inducing them to carry off and so disseminate the seeds. There seemed, however, some improbability in the idea that ants should be deceived as to their own sisters. M. Lüundstrom has found seeds of this species in ants' nests, but has not actually seen ants carrying them off, and I thought it would be worth while to determine this.

Accordingly I took 10 seeds and placed them just outside one of my domesticated nests of *Lasius niger*. A certain number of ants were outside, and I saw several come up to the seeds, but they took no notice of them. I left them lying there for two days. I then tried them with another nest, the roof of which consisted of two plates of glass, side by side, but with an interval between them. I placed the seeds in this interval, and uncovered one of the sides. The ants immediately began carrying the pupæ which were thus exposed to the light to the other, covered part of the nest, in doing which they necessarily passed close to the seeds, but they did not take the slightest notice of them. This operation was finished by 11 A.M., and I left them undisturbed till 12, the seeds remaining unnoticed and untouched. I then moved the cover from one half of the nest to the other, and the ants immediately began transporting the pupæ to the shaded half. One or two of them examined the seeds, not one of which, however, was moved. This took about an hour. At 4 P.M., however, three of the seeds had been carried in, and the next day, at 7 A.M., two more seeds had been carried in. I then removed them, and put them just outside one of my nests of *F. fusca*.

Aug. 31. 7 A.M. None have been touched. I now put the covering close to, but not over them. The ants took no notice of them.

Sept. 2. I now placed them just in the entrance of the nest and covered over a part just outside. The ants collected as usual under the cover. I then removed the cover just inside the nest, so that the ants to reach it had to pass among the seeds. They, however, came in, but did not move a single seed. I once again moved the cover outside, and they followed it as before, but without moving the seeds.

So far as these observations go it would seem that *F. fusca* takes no notice of these seeds, but that they really are under certain circumstances carried off by *Lasius niger*.

WASPS.

Mr. and Mrs. Peckham have published in the 'Proceedings of the Natural History Society of Wisconsin '* a very interesting paper on the special senses of wasps, and their conclusions concur closely with mine.

It appears from their observations that some wasps stay out all night and return early in the morning before the others begin coming out. For instance, on the 18th Aug. the first wasps left the nest at 7.25; 10, however, had already returned, 3 of them before 5 A.M. It appears from their observations that the average time a wasp is absent from the nest, that is the average length of each excursion, is 43 minutes. They observe that this may appear inconsistent with my observations, when the trips were shorter and more numerous, one of my wasps having paid me 116 visits in 15 hours and a half. But, as they justly observe, the cases are not comparable. My wasps and theirs were like Jacob and Ishmael—mine had everything ready prepared for them, theirs had to hunt for themselves.

As regards the sense of hearing, they repeated some of my experiments with the same results. They seem to consider that as regards the sense of colour their conclusions are somewhat at variance with mine.

As regards the supposed sense of direction they say †:—"Sir John Lubbock, in dealing with the sense of direction in ants, concluded, after a number of observations, that they were endowed with this sense in a high degree. Subsequently he discovered, quite accidentally, that the ants found their way by observing the direction in which the light was falling." My conclusion was, however, the result of many observations carried on under varied conditions, and I should hardly call it an accident.

They came to the conclusion, as I had done, that wasps have no sense of direction, that is to say in the form of a mysterious additional sense, but that, if they do not know where they are, they rise higher and higher into the air, circling as they do so, until they discover some high treetop or other object that had before served them as a landmark, and that in this way they are able to make their way home. This entirely tallies with my own conclusion. It is interesting as showing that the vision of wasps must be good for somewhat distant objects.

They also found, as I had done, that their memory varied greatly in different individuals.

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* April 1887.

† Proc. Nat. Hist. Soc. Wisconsin, April 1887, p. 113.

Lastly, I give two illustrations which will convey an idea of some of my ant-nests.

That on p. 129 represents about a quarter of one of my frames. The shaded part represents the earth, which will be seen to have been arranged by the ants into a sort of circular fortification, or zereba, access to which is obtained by one or two tunnels, not visible in the illustration, and to which a pathway leads from the entrance.

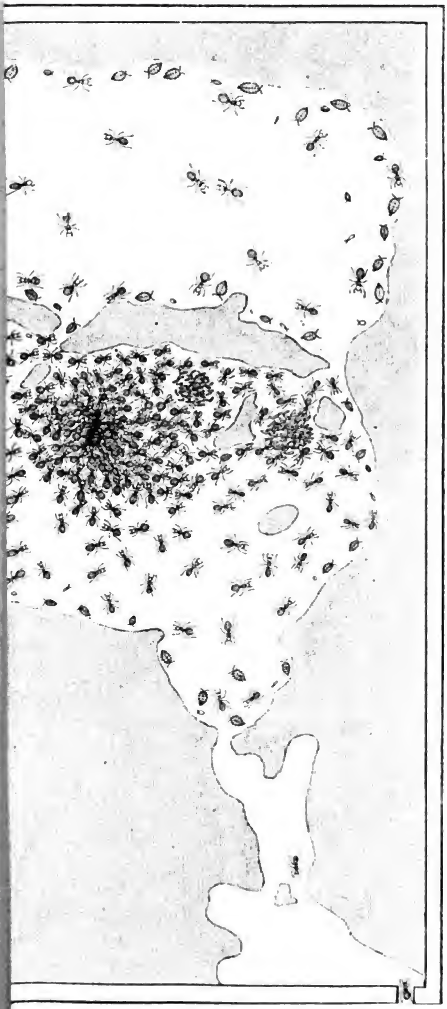
The second (facing this page) represents a nest of *Lasius niger*. It shows the entrance, a vestibule, and two chambers, in the outer and larger one of which the ants have left some pillars, almost as if to support the roof. The queen is surrounded by workers, those in her immediate neighbourhood all having their faces turned towards her. There is a group of pupæ, and several of larvæ, sorted as usual according to ages. There are also a number of the blind woodlice (*Platyarthrus Hoffmanseggii*).

Notes on some of the Birds and Mammals of the Hudson's Bay Company's Territory, and of the Arctic Coast of America. By John Rae, M.D., LL.D., F.R.S., &c. (Communicated by G. J. Romanes, F.L.S.)

[Read 16th February, 1888.]

During twenty years' residence in various parts of the Hudson's Bay Company's Territory, embracing the extreme south of the shores of James's and Hudson's Bays, and north to the Arctic Sea, I have had, as a sportsman, many opportunities of devoting considerable attention to the habits and peculiarities of animals, especially birds, over a very extensive field of observation, the result of which I shall attempt to give in the following remarks, some of which may possibly be new, other points disputed or perhaps already well known.

My first ten years were spent at Moose Factory, the principal depot of the Hudson's Bay Company in the Southern Department, lat. 51° N., long. 81° W., where the marshes along the coast form the favourite feeding-grounds of a variety of geese, ducks, &c. on their migrations to and from their breeding-places in the north. A great part of my spare time at these seasons, spring and autumn, was spent in shooting these birds, and at the same time acquiring some knowledge of their peculiarities.



llars, and inner room; the queen surrounded by workers;
the blind woodlice (*Platyarthrus Hoffmanseggii*).

First let me notice that magnificent bird the Canada goose (*Anser canadensis*), probably one of the finest of its kind in the world. This is the earliest arrival of the waterfowl migrants in spring, and makes its appearance at Moose with extreme regularity on the 23rd of April, St. George's day. So much is this the case that, during the ten years of my residence there, we had on every St. George's day a goose for our mess dinner, first seen and shot on that day, and this I learnt from older inhabitants had been the case for many previous years. I may add that this bird arrives with equal punctuality at York Factory in lat. 57° N., 450 miles further north, but a week later.

The Cree Indians, both at Moose and York Factory, assert positively that a small brown bird uses this goose as a convenient means of transport to the north, and that they have been often seen flying off when their aerial conveyance was either shot or shot at. The little passenger has been pointed out to me, but I have forgotton its name, and it certainly makes its appearance on the shores of Hudson's Bay at the same date as this goose, which, by the way, is the only kind that is said to carry passengers *. The natives of the McKenzie River, more than 1000 miles to the north-west, tell the same story. From my observation I am led to believe that there is another species of the Canada goose, much larger, but less numerous †. The male of this larger bird is distinguished by a ruddy-brown colour of plumage on the breast, by the greater loudness and sonorousness of its call, and by its much greater size, so that a difference is made in the quantity served out as rations to the men. The line of flight is also different, as they generally pass by Rupert's River about 100 miles east of Moose, but a few are sometimes to be obtained at the latter place, which afforded me an opportunity of comparing them with the more common or smaller kind. This *Anser canadensis* (major?), instead of being seen feeding in the marshes as the others do in autumn, chiefly frequents the higher and more rocky grounds on the eastern shores of James's Bay, where its principal food consists of berries of various kinds.

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* Since this paper was read, an article by J. E. Harting, on "Small birds assisted on their migrations by larger ones," has appeared in the Natural History columns of 'The Field' of March 31st, 1888, in which will be found much additional information on the subject.—J. R.

† Baird, Brewer, and Ridgway in their 'Water Birds of North America' recognize two species of Canada Goose—a large species with 18 to 20 tail-feathers, and a smaller one with 13 to 16 tail-feathers. Each of these supposed species they subdivide into two races, a grey and a brown one. Dr. Elliott Coues, in his 'Key to North-American Birds' (2nd ed. 1884, p. 689), remarks "there seems little probability of establishing good characters for more than one species of the *canadensis* group, with probably four varieties:—(1) large, no collar (702, *canadensis*); (2) small, no collar (704, *hutchinsi*); (3) large, collared (702 a, *occipitalis*); (4) small, collared (703, *leucoparcia*)." The two larger ones both have 18 tail-feathers; the two smaller ones 16 only.—Ed.

By far the most numerous of the goose tribe that visit the Moose marshes in the autumn are the snow goose, or white-wavy (*Anser hyperboreus*), and the blue-winged goose of Edwards (*Anser cærulescens*). These birds resemble each other very much in size, call, and form, but not in colour; and as they often feed in proximity, the blue goose was for a long time supposed to be merely the young of the snow goose; an erroneous opinion, which I endeavoured to correct in a little book published in 1850 by Boone, entitled 'Expedition to the Shores of the Polar Sea 1846–47.' *

These snow and blue-winged geese have a peculiarity I have never noticed in any other species. Previous to taking their southern flight from Hudson's Bay some time in October, they remain for several days almost constantly on the open sea, washing themselves, taking sudden and rapid flights, apparently having a "happy time," but they are never seen feeding. They are at this time very fat, and when shot, their stomachs and intestines are found to be entirely empty, resembling in this respect salmon, I am told, prior to, and in preparation for, their hard work in ascending rivers to their spawning-beds. After this period of fasting, ablution, and exercise has been gone through, the birds are evidently ready to start on their flight of some hundreds of miles. On the first favourable opportunity, which means a northerly wind, they take wing in batches of fifty or more, circling round until they attain a safe altitude, and then bear away on a true southerly course, never resting until they reach winter-quarters, on the shores or swamps of the Southern States †.

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* The specific distinctness of these two geese is generally admitted by modern ornithologists.—ED.

† I may mention that 45 years ago the blue-winged and white-wavy geese visited Moose in about equal numbers, as they still do; whereas at Albany, 100 miles to the north, there were great numbers of the white bird and scarcely a blue-wing to be seen. Now the two kinds are about equally abundant there, whilst at Rupert's River, 100 miles east of Moose, now, as formerly, the blue-winged birds are alone met with.—J. R.

The Canada goose, on the contrary, stops by the way to feed, especially on the lakes and swamps where there is wild rice, which makes both geese and ducks much finer eating than any other kind of food I know. Both the white and blue wavy are excellent eating, and one of them with a pound of flour or bread, is given as a day's rations, and is much liked by the men, especially when fresh. Many thousands are annually cured with salt, and packed in barrels for use at the Hudson's Bay Company's stations on the coast; and the Indians bone and dry a great number for winter food.

All species of grouse in British North America have a well known habit of passing the night under the snow, during the winter, to protect themselves from the cold; but possibly a practice which most of them follow more or less when the snow is not too hard packed may not have been generally observed. The bird is not content to make its resting place close to the door by which it has entered the snow, but usually bores a tunnel a few inches under the surface, three or more feet in length, before settling down for the night. The cause for going through so much, apparently, useless labour was at first difficult to understand, for its bed would have been equally warm had the bird remained within a foot of where it had entered the snow, but a little more experience taught me to admire the acuteness and intelligence of the proceeding, for during my walks in the woods I frequently came to places where a fox, lynx, or other carnivore had in the night approached cautiously (judging by the short steps) and made a long spring on the entrance hole; the occupant was not there, however, but had flown up 3 or 4 feet off, as seen by its exit in the snow, and was thus saved from almost certain death.

The prairie-hen, which is fairly numerous near Moose, shows great carefulness in this respect, and in very cold weather takes its "siesta" between breakfast and supper under the snow, out of which I have often seen them pop their heads, without taking wing, before I had got within shot, no doubt to observe if an enemy were approaching.

Without counting the small white grouse peculiar to the Rocky Mountains, I believe there are three other species to be found at or near the Arctic coast.

First and chief among these is the Willow-grouse (*T. saliceti*), by far the most numerous, and forming an important article of food for the Indians living near the coast of Hudson's Bay. These birds extend their breeding-grounds up to the Arctic shores of America, but as a rule do not extend their migrations to the large islands further north.

Dr. Bell says:—"The summer plumage of *Tetrao saliceti*, the cock bird, is exactly the colour of the English cock pheasant with the exception of the wings, which have a good deal of white, and in winter the white of the living bird has a beautiful delicate rosy tint, which forms a considerable contrast with the surrounding snow." * This description is somewhat misleading. The plumage of the cock willow-grouse in summer resembles as nearly as possible that of the Scottish grouse, with the exception that the primary feathers of the wings of the former are *always* white. The "delicate rosy tint of the white plumage" is rarely seen, and only in beautiful warm sunny winter or spring days, *never* on a cold winter day. In the spring, or pairing season, the call and peculiar habits of the Willow and Scottish cock Grouse exactly resemble each other.

The Rock Grouse (*Tetrao rupestris*) is so well marked by its smaller size, its more slender beak, and the black patch extending from the angle of its mouth to the eye in the male, that it cannot be mistaken for any other.

A third species differs considerably from *Tetrao saliceti* and *rupestris*, being fully as large as the former, but the bill seems shorter, its feet smaller, and its call perfectly different from either of the others; it is also found further to the north. I saw a good many males (the hens were nesting) on Wollaston Land, lat. 69° N., in May and early June, and managed to shoot a few, although they were very wild, possibly with the intention of leading me away from the nest †.

At Toronto, Lake Ontario, Canada, an island forms an excellent harbour. Along the outer side of this island an immense number of a small sandpiper, called "black heart" (the Dunlin, *Tringa alpina pacifica*), pass northward every season on the 23rd April (St. George's day) and are not seen on any other day, except, perhaps, some wounded ones on the 24th that cannot continue their flight. This flight is so well known that many sportsmen line the shores of the island on the day named, and hundreds of these pretty little birds, which are good eating, are shot. Persons who have resided many years in Toronto have told me that they did not remember an instance of variation in the date of the arrival of these birds.

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* See "Notes on Birds of Hudson's Bay" by Robert Bell, M.D. Proceedings of the Royal Society of Canada for 1882, vol. i. p. 49.—J. R.

† There is, I think, a specimen of this bird in the Natural History Museum at South Kensington called *Tetrao mutus*, but certain distinguished naturalists do not believe in it. I brought one or two specimens from the Arctic regions in 1847, which were presented to the British Museum.—J. R.

Over almost every part of the wooded country of British North America, east of the Rocky Mountains, the American hare (*Lepus americanus*), usually called the "rabbit" by the Hudson's Bay Company's people, is to be found in more or less abundance, and it may not be generally known that every ten years these animals are attacked by an epidemic so fatal, that from being very numerous they gradually die off until scarcely one is to be seen. The survival of the fittest then begins to increase, and at the end of ten years they are again at their maximum. I have myself seen two of those cycles, and know men in the Hudson's Bay Co's. service, who have witnessed four or five of such events.

The latest years of abundance were 1885 and 1886, the hares having increased gradually from 1880–81, which were years of scarcity. The curious thing is that this takes place in the same years over an extent of country about as large as one fourth of Europe. It has been asserted by distinguished naturalists, among them by my friend Sir John Richardson, that the hares migrate; but this cannot be the case, for it is not known where they go to, besides they are found sitting in their "forms" dead, usually under small pine or spruce trees, the branches of which grow close to the ground. I account for the disease in this way. The hares do not spread themselves broadcast all over the country, but live in colonies extending over a square mile or more, where the trees and plants on which they feed are abundant, and here they become so crowded together that the ground gets poisoned by their excreta, as is the case with domestic poultry when kept too long on the same land without being cleaned or shifted, and hence disease. The grouse disease in Scotland I attribute to the same cause, when too large a stock has been left on the moors. When the grouse "pack," they have in winter some favourite resort to which they fly during storms (chiefly from the west) for shelter, and I have seen such places perfectly covered with droppings, even in Orkney, where grouse are never very numerous.

The effect of these epidemics among the hares is peculiar, and affects both the Indians and some of the fur-bearing animals, as I shall endeavour to explain.

When the hares are abundant, an Indian and his family pitch their tent among them in winter, and cut down a number of the trees, part of which forms the hares' favourite food, then make barriers of small pine trees and brush, through which gaps are cut to allow the hares to run through. Allowing them a short time to fatten up on the abundant food provided for them, a hundred snares, or more, are set in the openings of the barriers, and these snares are attended to by the wife and children of the hunter, whilst he sets up a number of traps in two or three directions to the distance of perhaps eight or ten miles from his tent, each of which he visits two or three times a week to bring home the fur-bearing animals caught, chiefly fox, lynx, fisher, and marten, taking with him on each visit a supply of fresh baits. The Indian is thus carrying on his winter hunt in the most advantageous manner, the hares attracting the carnivora above named to his traps, whilst at the same time they supply, without any difficulty, an abundance of food and the most comfortable winter blankets known. The making of these blankets is peculiar; the hare skins, after being cut into strips, are stitched end to end, and plaited so loosely that the finger can be poked through them in any direction, yet a person can sleep comfortably wrapped up in one of these on the coldest night, with the temperature say 40° below zero, without any fire.

When the hares become scarce, not only has the Indian to travel about in search of large game, or go fishing to obtain food for himself and family, but the fur-bearing animals have also to wander abroad; consequently the Indian cannot catch so many hares, and they have time to increase and multiply until a season of abundance again comes round.

The house-building habits of the muskrat in nearly every part of British North America are well known, but there is one plan to which it sometimes resorts under certain circumstances which appears to show great intelligence in enabling it to get its food more readily. The muskrat, when about to build its house, selects a pond or swamp of good pure water, on the bottom of which grow the plants which constitute its winter supply of food. If the pond or swamp is of considerable extent, and the house a large one containing many rats, they, when the water begins to freeze in early winter, keep several holes open in the ice in different directions, and at a distance from the house, and build a little hut of mud and weeds (just large enough to hold one rat comfortably) over each hole which—especially when covered with snow—prevents it freezing up. These huts enable the rats to extend their feeding ground to all parts of the pond, which could not be reached at all, or with difficulty, from the house if they had to swim home every time with a mouthful of food, to eat it. With these little shelters they are saved a great amount of labour and are enabled to reach all the food in the pond.* I remember, when on a snow-shoe journey, one of my men went very quietly up to one of these miniature mud huts, and knocked it over with his axe, disclosing a live rat with some of the food it had been eating. The practice of building these little eating huts is by no means common, and does not seem to be resorted to when the pond is of moderate dimensions, and all parts of it can be reached from the house without difficulty.

I am not aware if it is generally known that the lemmings (*Myodes hudsonicus*, &c.) of North America migrate much in the same manner as do those of Norway and Sweden. When travelling in June 1851 southward from the Arctic coast along the west bank of the Coppermine River, and north of the Arctic Circle, we met with thousands of these lemmings speeding northward, and as the ice on some of the smaller streams had broken up, it was amusing to see these little creatures running backwards and forwards along the banks looking for a smooth place with slow current at which to swim across. Having found this, they at once jumped in, swam very fast, and on reaching the opposite side gave themselves a good shake as a dog would, and continued their journey as if nothing had happened. At that date the sun was above the horizon all hours of the 24, and we were travelling by night to avoid the snow-glare in our eyes, the sun being then in our rear. As the lemmings appeared to travel only by night, we should not have seen them had we been travelling in the daytime, for they then hide themselves under the snow, or stones. The man who was carrying our cooking utensils and small supply of provisions, having, when fording a stream, been swept into a deep hole by the current, whereby his whole load was lost, we had, for a day or two, to live chiefly on lemmings roasted between thin plates of limestone, and found them very fat and good. Our dogs easily killed as many as they required. Prior to this, whilst on the coast, crossing the ice to islands some miles distant, a lemming was noticed defending itself most gallantly against the attack of two large gulls, which continued swooping down at it, but were kept at bay by the brave little animal turning on its back and squealing loudly. I ran up and was in time to drive away its dangerous opponents, and place it in safe shelter under a piece of ice.

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* The beaver, especially when its dam is large, scrapes holes in the banks from under water upwards until above the water-level, to which it retires to feed instead of going back to its house.—J. R.

Occasionally large numbers of lemmings are found drowned along the shores of James's Bay, but as they are generally seen after a very high tide, it is uncertain whether they are then migrating, or merely caught by the high tide on their native grounds. As soon as snow falls to any considerable depth, the lemming leaves its summer quarters in the ground, and builds a bed of grass and moss as a winter shelter, from which it bores under the snow in one or more directions to obtain food. They do not seem to hibernate during the winter, for when wintering in a snow-hut at Repulse Bay in 1853–4 I used to hear them scratching tracks through the snow throughout the cold season*.

The Arctic hare (*Lepus glacialis*), of which I have seen and shot a good many, shows a considerable amount of intelligence in its efforts to throw foxes, wolves, and other enemies off the scent. It seems to have been eminently successful in this respect with the crew of McClure's ship when wintering in Prince of Wales's Strait, if it were not from bad shooting on the part of the men, for we are told that although hundreds of hares were seen, the total bag in a month was only seven hares!

The Arctic hare, after its night's feed, usually goes some distance from its feeding-ground before settling down in its form for the day. When following up the track, I was at first extremely puzzled to find all at once a complication of tracks, and on going a little further found no track at all. On retracing my steps and carefully examining the snow, I observed two very small marks, at least 20 feet distant, from the main track. A succession of two or three similar long jumps followed, and a very little experience taught me that the hare was always crouching near; usually close to some large stones or rock uncovered by snow. These long jumps were invariably made to *leeward* for obvious reasons, because if to windward a fox would have scented his prey.

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* Many lemmings were seen at the winter quarters of the Nares Arctic Expedition, in lat. 82°, and a large "cache" of dead ones was found, made by a white fox.—J. R.

Even after becoming acquainted with this artful dodge, the hare must be stalked with caution. Being all white except the tips of its ears, it is not easily seen when nearly buried in the snow, and when discovered the sportsman must dissemble, and pretend that he has not seen it, walking in an oblique direction, approaching, but at the same time as if passing by, never looking directly at the game. When near enough he should wheel suddenly round and fire. If this plan be not adopted, the hare will very generally bolt round the rock, and escape under its shelter. This may be called *pot* shooting, but the best of sportsmen have often to do the same thing with ptarmigan in the Scottish mountains, when these birds fly round a rock and are out of sight in an instant, if not shot before taking wing.

Copepoda of Madeira and the Canary Islands, with Descriptions of New Genera and Species. By ISAAC C. THOMPSON, F.R.M.S. (Communicated by Prof. HERDMAN, F.L.S.)

[Read 17th November, 1887.]

(PLATES X.-XIII.)

DURING the spring of 1887, in company with Mr. W. S. M'Millan, of Liverpool, I visited Madeira and the Canary Islands with the object of collecting and examining the pelagic fauna at the various convenient stopping-places.

We took dredge and tow-net, and all the necessary appliances for the examination and preservation of specimens, and were fortunate in securing a large mass of material.

It is intended in this paper to treat of the Copepoda only; and as the dredging operations were neither so practicable, nor fruitful in results as the tow-netting, it was to the latter that we devoted chief attention, all the Copepoda collected being free-swimming species.

We used one of the very fine-meshed tow-nets of the 'Challenger' pattern, and immediately preserved the captures in a medium which I have always found useful for small Crustacea, composed of glycerine, alcohol, and water in the following proportions:—

$$\left.\begin{array}{ll}\text{Glycerine......} & \text{1 part}\\ \text{Proof-spirit...} & \text{2 parts}\\ \text{Water ....} & \text{1 part}\end{array}\right\}\text{ adding 1 per cent. of carbolic acid.}$$

In this solution the colours (and they are very varied in the Copepoda) are well preserved, and the tissues are rendered sufficiently transparent for observation under the microscope without further treatment.

We longed to cast a tow-net while traversing the fifteen hundred miles of Atlantic waters that intervened before reaching our first destination, Madeira, and improvised a long tough canvas bag, weighted, with a wide-necked bottle at the bottom end, for the purpose; but the speed of the vessel was too great to allow of any captures. The mails could not give way to the study of biology, so our genial captain would not allow any temporary stoppage; but the death of a poor fireman on the fourth day out necessitating a funeral pause of a few minutes, we took advantage of the opportunity by getting a haul; and the tow-net brought up sufficient to occupy us and relieve the monotony of the rest of the voyage. The haul was almost entirely composed of Copepoda: *Calanus finmarchicus*, *Centropages typicus* and *C. brachiatus*, *Dias longiremis*, and a few other species, nearly all found on our British coasts.

The deep-blue transparent waters of Madeira proved very fruitful both in number and variety of Copepoda, Funchal Bay being our hunting-ground during two visits. Thence to Teneriffe, where we anchored for a few hours in the Santa Cruz harbour, and, as at Madeira, collected enough Copepoda to occupy us many months in examining and working out.

Grand Canary was our next destination, and there we spent many days dredging, collecting, and tow-netting at various parts of the island. The absence of any shelter or harbour at Las Palmas rendered dredging difficult, for we had to take eight men to manage the boat, the sea being seldom at all smooth. And, from some cause or other, the tow-netting results obtained here were certainly much poorer than those of the more sheltered bays of Madeira and Teneriffe.

Returning to Teneriffe, we crossed the island from Santa Cruz to Orotava, grandly situated on the north side directly under the Peak, and famous for its splendid climate and scenery. We found the waters of the ocean here very plentiful in Copepoda, and on various occasions collected a large amount of them. One of these occasions was long after sunset, and it is worthy of note that the Copepoda then taken were little different in point of number or species from those taken in daylight, although with the night-haul were a largely increased number of Schizopoda, some of them highly phosphorescent.

From a pretty thorough examination of the material obtained at the various islands of the Canaries and Madeira, it seems evident that their Copepodan fauna varies in quantity rather than specifically. For, excepting several cases where one or two specimens only of a species were found, which probably indicated the rarity of that species, their geographical distribution appeared to be general amongst the islands.

Sixty-four species in all were obtained, as enumerated below. Of these six are new to science, and three of them required new genera. (See Plates X. to XIII.)

Of the sixty-four species, twenty-two are known in British waters; and of these, thirteen belong to the family Harpacticidæ.

Following the classification given by Brady*, the sixty-four species are distributed into families as follows:—

Calanidæ	30	species.
Cyclopidæ	4	„
Harpacticidæ	16	„
Corycæidæ	11	„
Artotrogidæ	3	„

Description of the Species collected.

Family CALANIDÆ.

CALANUS FINMARCHICUS, *Günner.*

C. VALGUS, *Brady.*

C. PROPINQUUS, *Brady.*

This species, like the two preceding, is widely distributed. A high power of the microscope (×400) shows very fine hairs on the inner margin of the terminal spines of the swimming-feet, not mentioned by Brady in his description of the species.

C. TONSUS, *Brady.*

C. GRACILIS, *Dana.*

Both found very sparingly.

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* 'Monograph of British Copepoda,' Ray Society, 1876–78 & 1879.

CALANUS PAVO, *Dana.*

This species occurs in considerable numbers in the gatherings from Madeira and Teneriffe; but the elegant peacock-tail plumes figured by Dana (Crustacea of U. S. Exploring Expedition) have become detached in all the specimens.

PARACALANUS PARVUS, *Claus.*

One or two specimens only of this rare form were taken at Orotava, Teneriffe.

EUCALANUS ATTENUATUS, *Dana.*

E. SETIGER, *Brady.*

Brady remarks upon the "mimetic resemblance" of this species to *Calanus finmarchicus.* Our specimens do not bear out this remark; and the absence of terminal spines to the swimming-feet of this species is a distinguishing feature.

RHINCALANUS CORNUTUS, *Dana.*

R. GIGAS, *Brady.*

PSEUDOCALANUS ELONGATUS, *Boeck.*

PLEUROMMA ABDOMINALE, *Claus.*

LEUCKARTIA FLAVICORNIS, *Claus.*

SCOLECITHRIX DANÆ, *Lubbock.*

S. MINOR, *Brady.*

EUCHÆTA PRESTANDREÆ, *Philippi.*

CANDACE TRUNCATA, *Dana.*

C. NIGROCINCTA, n. sp. (Pl. X. figs. 1–6.)

Length $\frac{1}{10}$ inch. Head-somite distinct from thorax. Body oval, rounded in front; posterior segment terminated by two lateral spines. Anterior antennæ 23-jointed, bearing several spinous processes on inner margin, and short setæ at the termination of each joint. The 8th, 9th, 10th, and 11th joints (fig. 1) are deeply pigmented with a blackish-brown colour, the same pigment tinging the setæ of the posterior antennæ and the terminal spines of the swimming-feet. Posterior antennæ (fig. 2) similar to that of *C. truncata*, but with fewer terminal setæ. Anterior foot-jaws (fig. 3) 2-jointed, large and powerful, with two small claw-like spines on basal joint, and five large ones on second joint. Posterior foot-jaws small, 7-jointed. First four pairs of swimming-feet (fig. 4) alike; inner branch has one joint only; outer edge of main branch is finely serrated. Pigment does not extend above the terminal spine, which is somewhat bent and finely serrated and clothed with dark hairs on dorsal side. Fifth feet of male (fig. 5) each 3-jointed, the right foot having extension on inner side of middle joint, both terminated by two small claws. Abdomen of male (fig. 6) 3-jointed, the third being nearly equal in size to the other two; caudal segments about twice as long as broad, terminated by short strong setæ.

Several specimens of this strongly marked form were taken at Orotava, Teneriffe, all of which appear to be males.

It has strong points of resemblance to both *Candace pachydactyla* and *C. truncata*, Dana, but is evidently distinct from both. The dark rings on the anterior antennæ distinguish it at a glance.

CANDACE BREVICORNIS, n. sp. (Pl. X. figs. 7, 8.)

Several specimens of a *Candace* were taken at Orotava and at Santa Cruz, Teneriffe, which, although corresponding in most respects with *C. truncata*, Dana, differ in some particulars which are of sufficient importance to render it specifically distinct.

In the first place the anterior antennæ are composed of eighteen joints only, while *C. truncata* has twenty-four. Then the first four pairs of swimming-feet (fig. 8) are the same as in *C. truncata*, except that in our specimens, to which I propose to give the name *C. brevicornis*, the setæ are all elegantly plumed, much resembling minute black feathers. No fifth feet can be made out in any of the specimens obtained. Abdomen only 2-jointed, the caudal segments being long and straight, while in *C. truncata* they are somewhat stumpy and divergent. The basal joint of the abdomen is less triangular than in *C. truncata*. Our specimens are probably all females.

DIAS LONGIREMIS, *Lilljeborg*.

ACARTIA LAXA, *Dana*.

A. DENTICORNIS, *Brady*.

In all our specimens of both species of *Acartia* there is a long recurved spine at distal end of first joint of each anterior antenna, which does not appear to have been previously described.

DREPANOPUS FURCATUS, *Brady*.

Several females of this species were found, but no males; a similar experience to Brady's. His specimens of this species ('Challenger' Report on the Copepoda, p. 77) were sparingly found in three remarkably distinct areas.

TEMORA DUBIA, *Lubbock.*

Very abundant in all the gatherings.

ISIAS CLAVIPES, *Boeck.*

First abdominal segment of female has two remarkable trifid spines on ventral side, not described by Boeck or Brady. I first noticed this point in specimens taken in Liverpool Bay. The fifth feet of male also differ considerably from Brady's drawing.

CENTROPAGES BRACHIATUS.

C. TYPICUS.

C. VIOLACEUS.

Our specimens of the latter are most profusely and elegantly adorned with violet plumose setæ.

MECYNOCERA, n. gen.

Cephalothorax 6-jointed; head united with thorax; abdomen 4-jointed in the male, 3-jointed in the female. Anterior antennæ 23-jointed, very long. Outer branch of posterior antennæ 3-jointed, the inner branch 7-jointed. Mandibles and maxillæ well developed. Anterior foot-jaw 3-jointed and very muscular, and, like the posterior, clothed with strong plumed setæ. Swimming-feet alike in both sexes, fifth feet entirely wanting.

MECYNOCERA CLAUSI, n. sp. (Pl. XI. figs. 1–4.)

Length $\frac{1}{25}$ inch. Rostrum bifid and very slender. Anterior antennæ 23-jointed, alike in both sexes, about twice the length of the entire animal (fig. 1); the 11th, 12th, and 13th joints of left antennæ only edged with fine saw-teeth (fig. 2). Basal portion of both antennæ bear several short setæ and a few long ones, and at intervals, and especially at apex, are several long whip-like setæ. Posterior antennæ very muscular; the outer branch 3-jointed, the inner 7-jointed and terminated by spreading setæ. Mandibles finely toothed. Maxillæ well developed, with two spreading setiferous branches and broad rounded palp. Anterior foot-jaw 3-jointed, and, like the posterior, which is small, bearing a large number of plumose setæ.

Swimming-feet (fig. 3) have small hooked spines at ends of joints, but no terminal spines besides the strong spinous setæ.

Fifth feet wanting in both sexes. Abdomen of male (fig. 4) 4-jointed, female 3-jointed, the basal joint of latter being somewhat heart-shaped, and having doubled circular genital apertures. The third abdominal joint is divided longitudinally, the intervening span being filled with hyaline membrane. Caudal terminations in female divergent, in male less so; both terminated by four plumous setæ on each side. Colour reddish brown.

Males and females were both plentiful, and taken by surface tow-net at all the places visited. Indeed this species seemed to be more widespread than any other.

Claus, in his memoir 'Die freilebenden Copepoden' &c., gives a figure (pl. xxxii. fig. 17) of a form which is evidently this species, although the anterior antennæ are not correctly represented. He has informed me in a letter that the material at his disposal was not sufficient to enable him to describe the species. I have therefore much pleasure in naming this form, which is so abundant at the Canary Islands, after the distinguished naturalist who first discovered it.

Family CYCLOPIDÆ.

OITHONA CHALLENGERII, *Brady*.

O. SPINIFRONS, *Boeck*.

O. PLUMIFERA, *Dana*.

O. SETIGER, *Dana*.

All four species of this delicately organized genus were found fairly plentifully and generally distributed. The long feathery red-coloured plumes of *O. plumifera* give the species a very graceful appearance, and readily distinguish it from the others.

Family HARPACTICIDÆ.

LONGIPEDIA CORONATA, *Claus*.

SETELLA GRACILIS, *Dana*.

Various specimens of this species collected differed considerably from each other in colour and form, but not sufficiently to be considered specific.

EUTERPE GRACILIS, *Claus*.

This minute species, hitherto considered very rare, we found widely distributed but not numerous.

DELAVALIA ROBUSTA, *Brady & Robertson.*

DIOSACCUS TENUICORNIS, *Claus.*
One specimen only found at Orotava, Teneriffe.

LAOPHONTE CURTICAUDATA, *Boeck.*
L. SERRATA, *Claus.*
DACTYLOPUS TISBOIDES, *Claus.*
THALESTRIS MYSIS, *Claus.*
T. RUFOCINCTA, *Norman.*
WESTWOODIA NOBILIS, *Baird.*
HARPACTICUS CHELIFER, *Müller.*
PORCELLIDIUM VIRIDE, *Philippi.*
IDYA FURCATA, *Baird.*

All found generally distributed, but none plentiful.

MACHAIROPUS, n. gen.

Head longitudinally rounded, terminating in long thin bifid rostrum. Anterior antennæ 12-jointed, about two thirds the length of cephalothorax; sparingly setiferous. Posterior antennæ long; the outer branch 3-jointed, the inner 2-jointed. Mandibles have very fine claw-like teeth; the palpi is two-branched, with long fine hairs.

Maxillæ have four strong serrated curved spines and numerous setæ. Posterior foot-jaw 2-jointed, having long sword-like spines with enlarged bases. Anterior foot-jaw small. Abdomen 2-jointed.

MACHAIROPUS SANCTÆ-CRUCIS, n. sp. (Pl. XII. figs. 1–5.)

Length $\frac{1}{15}$ inch. Rounded head (fig. 1) of a deep pink colour. Anterior antennæ (fig. 2) 12-jointed. Posterior antennæ (fig. 3) has long whip-like setæ, extending to the length of the anterior antennæ. Swimming-feet (fig. 4) have three joints to outer branch, and two joints to inner. Terminal spine narrow and finely serrated. Basal joints of swimming-feet have long spine on inner margin. Fifth feet (fig. 5) have one joint terminated by a long, stout, curved spine, with a small one at each side. First joint of abdomen is small, the second long, and wide in the middle. Caudal segments are about four times as long as broad, and are terminated by short non-plumose setæ.

One specimen only, sex undetermined; was taken by tow-net at Santa Cruz, Teneriffe.

SCUTELLIDUM TISBOIDES, *Claus.*

Family CORYCÆIDÆ.

CORYCÆUS VARIUS, *Dana.*

C. PELLUCIDUS, *Dana.*

C. LIMBATUS, *Brady.*

C. VENUSTUS, *Dana.*

C. SPECIOSUS, *Dana.*

All five species of *Corycæus* we found in fair abundance and widely distributed.

COPILIA MIRABILIS, *Dana.*

Found very sparingly.

LUBBOCKIA SQUILLIMANA, *Claus.*

Several specimens of both sexes of this striking species were taken at Teneriffe and Grand Canary.

ONCÆA OBTUSA, *Dana.*

The remarkable variety of colour in this species is worthy of note, especially when fresh. It ranges from olive-green to purple, blue, magenta, scarlet, &c. The colours are mostly retained if mounted in Farrants medium soon after capture.

SAPPHIRINA INÆQUALIS, *Dana.* S. SERRATA, *Brady.* S. METALLINA.	Fairly plentiful throughout the gatherings.

Family ARTOTROGIDÆ.

ACONTIOPHORUS ANGULATUS, n. sp. (Pl. XII. figs. 6–11, and Pl. XIII. figs. 5, 6.)

Length $\frac{1}{30}$ inch. Head united with first thoracic somite, which is rounded off at base (Pl. XII. fig. 6), the other somites of cephalothorax being angular. Rostrum (fig. 7) composed of two small projections with finely serrated edges. Anterior antennæ (fig. 8) 11-jointed, short, and gradually tapering from base to apex; second joint larger than the others, and from it proceed a number of long setæ; from seventh joint proceeds a long, narrow spine; there are several long setæ at the apex. Posterior antennæ (fig. 9) two-branched, the first being 3-jointed and terminated by two long lancet-shaped spines; the second has one joint, and is terminated by a long sword-shaped spine. First and second foot-jaws (figs. 10 & 11) each have a long apical claw, the first is composed of two, the second of four joints.

First four pairs of swimming-feet nearly alike, both branches 3-jointed (Pl. XIII. fig. 5); base and second joint of chief branch have very fine serration on inner edge formed by minute hairs. Fifth feet (Pl. XIII. fig. 6) are composed of two stout joints, the outer bearing a number of long setæ, some of them plumose; the outer edge of both joints has fine hairy serration. Caudal segments and terminal setæ are the same as in *A. scutatus*.

Siphon very long and slender, reaching to the ends of caudal segments.

One specimen only of this new species was taken at Funchal Bay, Madeira. The angular shape of the posterior segments of the cephalothorax readily distinguish it from *A. scutatus*, which it resembles in general characters.

ARTOTROGUS NORMANI, *Brady & Robertson.*

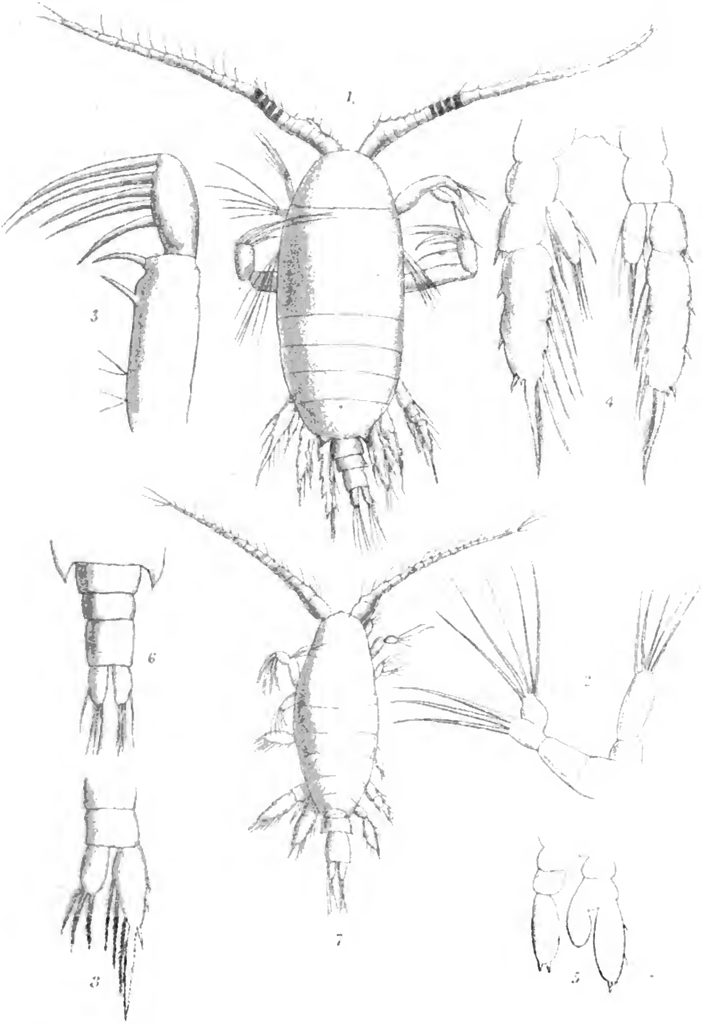
Found very sparingly.

CYMBASOMA, n. gen.

Cephalothorax elegantly boat-shaped, 4- to 6-jointed; head united with thorax. Anterior antennæ 5- or 6-jointed, broad and muscular. No posterior antennæ or foot-jaws. First four pairs of swimming-feet have a large basal joint, the two branches being each 3-jointed and terminated by strong spinous setæ. Abdomen in female 2-jointed, the first much larger than the second; and from the centre of the latter are attached the ova on long narrow branches.

CYMBASOMA RIGIDUM, n. sp. (Pl. XIII. figs. 1–4.)

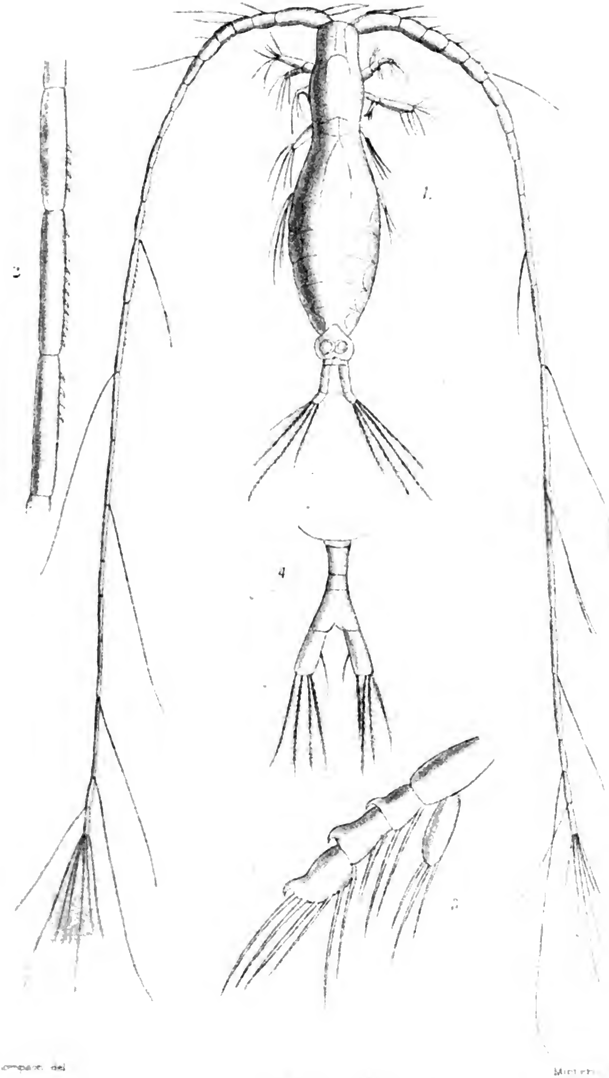
Length $\frac{1}{8}$ inch. First joint of cephalothorax (fig. 1) equal in length to the succeeding five, the last being much smaller than the others, and appearing as though part of the abdomen. Eyes long and kidney-shaped, with conspicuous brain below. Anterior antennæ (fig. 2) about eight times as long as broadest part, and terminated by two claw-like spines; the inner side of each antenna has five hooked spines (fig. 2). From two raised circumferences near the centre proceed long spinous setæ, and several smaller setæ are situated near the apical portion of the antennæ.



I. C. Thompson del.

Mintern lith.

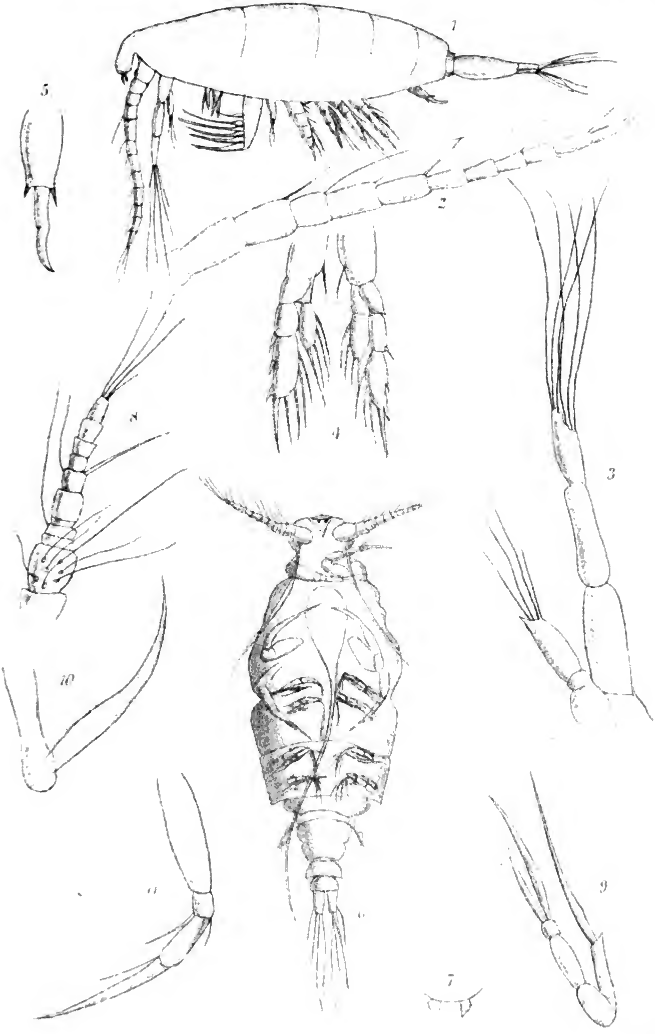
1-6. CANDACE NIGROCINCTA, n. sp. 7-8. CANDACE BREVICORNIS, n. sp.



Thompson del.

Mintern lith.

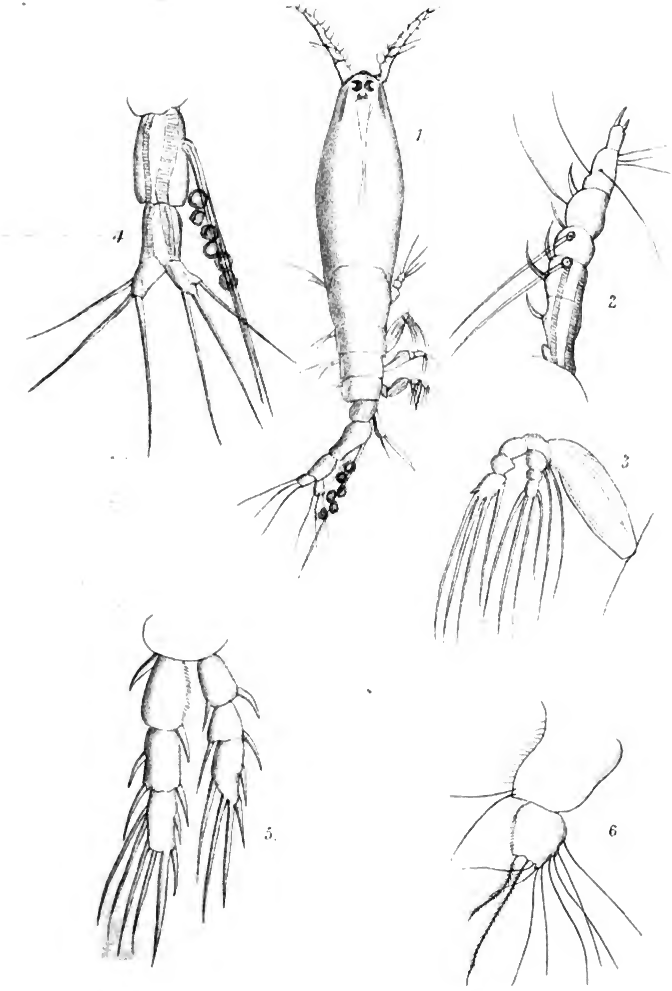
1–4 MECYNOCERA CLAUSI, n. sp.



I. C. Thompson del.

Mintern Bros. imp.

1-5 MACHAIROPUS [illegible] n. sp.
6-11 [illegible]NTROPHORUS ANGULATUS, n. sp.



I. C. Thompson del.

Mintern Bros. imp.

1–4. CYMBASOMA RIGIDUM n. sp.   5–6. ACONTIOPHORUS ANGULATUS n. sp.

First four pairs of swimming-feet (fig. 3) have strong muscular basal joints, from which proceed two 3-jointed branches with thick terminal setæ. Fifth pair of feet each composed of a long joint, at the apex of which are three strong spinous setæ. Abdomen very muscular; the caudal setæ are short, broad, and divergent, and are each terminated by three strong setæ.

One specimen only (a female) was taken in the tow-net at Orotava, Teneriffe. The lower part of the body is of a deep sepia colour. The animal is remarkably rigid and muscular.

Quite recently a second form, evidently belonging to this new genus, has been found in the channel between Puffin Island and Anglesea. It is probably a male, and I am describing it under the name *Cymbasoma Herdmani.* It will be figured along with other new species from Liverpool Bay in the second volume of the 'Proceedings of the Liverpool Biological Society.'

EXPLANATION OF THE PLATES.

Plate X.

Fig. 1. *Candace nigrocincta*, n. sp., male. × 250.
2. Posterior antenna of ditto. × 400.
3. First foot-jaw of ditto. × 400.
4. Fourth pair swimming-feet of ditto. × 400.
5. Fifth pair swimming-feet of ditto. × 400.
6. Abdomen and caudal segments of ditto. × 400.
7. *Candace brevicornis*, n. sp., female. × 250.
8. Fourth swimming-foot of ditto. × 400.

Plate XI.

Fig. 1. *Mecynocera Clausi*, n. sp., female. × 250.
2. Eleventh, twelfth, and thirteenth joints of left anterior antenna of ditto, showing saw-teeth. × 400.
3. Fourth swimming-foot of ditto. × 400.
4. Abdomen and caudal segments of male ditto. × 400.

Plate XII.

Fig. 1. *Machairopus sanctæ-crucis*, n. sp. × 250.
2. Anterior antenna of ditto. × 400.
3. Posterior antenna of ditto. × 400.
4. Fourth pair swimming-feet of ditto. × 250.
5. Fifth swimming-foot of ditto. × 250.
6. *Acontiophorus angulatus*, n. sp., female, × 250.
7. Rostrum of ditto. × 400.
8. Anterior antenna of ditto. × 400.

Fig. 9. Posterior antenna of ditto. × 400.
10. Anterior foot-jaw of ditto. × 400.
11. Posterior foot-jaw of ditto. × 400.

Plate XIII.

Fig. 1. *Cymbasoma rigidum*, n. sp., female. × 250.
2. Anterior antenna of ditto. × 400.
3. First swimming-foot of ditto. × 400.
4. Abdomen of ditto, with attached ova and caudal appendages.
5. First pair of swimming-feet of *Acontiophorus angulatus*. × 400.
6. Fifth foot of ditto. × 400.

Descriptions of some Genera and Species of *Galerucinæ*.

By Joseph S. Baly, F.L.S.

[Read 2nd February, 1888.]

The examination of some extensive genera of *Galerucinæ—Haplosonyx*, *Cerotoma*, and others—in which the anterior acetabula are described as closed or entire, has convinced me that the views expressed by myself in the Ent. Month. Mag. vol. xxiii. p. 268 are correct. In any long series of individuals belonging to these various genera I have almost invariably found some species in which, whilst certain specimens have the acetabula closed, others have them open, in some instances these opposite states occurring on the different sides of the same individual. This is strikingly the case in *Cerotoma* and *Monolepta*. Under such circumstances it must, I think, be conceded that the state of the acetabula cannot be regarded as a primary, even if it can be retained as a secondary character. It becomes therefore necessary to discover some other and more stable means by which to divide the *Galerucinæ* into primary sections. This, I venture to suggest, will be found in the form and structure of the hinder portion of the prosternum. In a large number of genera, for instance *Haplosonyx*, *Œnidea*, and numerous others, the prosternum, as in the Chrysomelidæ and the earlier groups of the Phytophaga, is produced just before its base into a distinct lobe or process, the sides of the lobe (in cases where the acetabula are closed) being connected with the apices of the epimera, whilst the hinder margin of the lobe is free, and usually applied to the anterior surface of the mesosternum. In a second large section of the family, represented by *Galeruca*, *Aulacophora*, &c., this subbasal lobe is entirely absent, the prosternum being connected without break with the hinder margin of the antepectus, or true hinder border of the under surface of the thorax.

In this group the acetabula are sometimes closed by the prolongation of the epimera across the base of the prosternum to meet in the median line, as in *Galeruca* and *Menippus*. On the presence or absence of the subbasal lobe, I would divide the family into two primary groups, taking as secondary ones those derived from the spines at the apices of the tibiæ, the bifid or appendiculated claws, and from the relative length of the elytral epipleuræ. My object in making these remarks is to justify the use of characters drawn from the form of this basal lobe as a diagnostic character in the new genera described in the present paper.

Of the genera mentioned or described below, the first five have the prosternum lobed; in the rest the lobe is obsolete.

Genus CHARIDEA.

Corpus elongatum, modice convexum. *Caput* exsertum, *oculis* rotundatis; *encarpis* elongatis, pyriformibus; *antennis* filiformibus; *palpis maxillaribus* articulo ultimo ovato. *Thorax* transversus, convexus, disco calloso. *Scutellum* trigonatum. *Elytra* parallela, modice transversim convexa, punctato-striata, interspatiis interdum costatis; *epipleuris* fere ad apicem extensis. *Pedes* robusti, simplices; *tibiis* apice muticis; *metatarsi* articulo basali ad duos sequentes fere æquilongo. *Prosternum* inter coxas distincte visum, ante basin lobatum; *acetabulis* anticis integris aut paullo apertis.

Type *Charidea punctato-striata*, Motsch.

This genus may be known from *Galerucella*, in which the typical species was placed by Motschulsky, by the lobed base of the prosternum; it ought to stand near *Œnidea*, but is separated from that genus by the punctate-striate and costate elytra, and by the non-incrassate palpi.

Although the two species placed by me in this genus differ in one having closed, the other open acetabula, they agree so entirely in all other characters that I have no hesitation in placing them under the same generic head.

1. CHARIDEA PUNCTATO-STRIATA, *Motsch. Etud. Ent.* ix. p. 25 (sub *Galeruca*).

Galeruca multicostata, *Jacoby, Proc. Zool. Soc.* November 1885, p. 146, tab. xlvi. fig. 7.

Hab. Japan.

In this species the anterior acetabula are slightly open.

2. **Charidea Fortunei.** Elongata, picea, nitida, antennis nigris, supra subnitida, pube suberecta grisea sparse vestita; thorace elytrisque sanguineis; thorace quam longo paullo latiore, fortiter punctato, disci medio bicalloso, callis lævibus; elytris parallelis, transversim convexis, fortiter punctato-striatis, utrisque bicostatis. Long. 2¾ lin.

Hab. Northern China; collected by the late Mr. Fortune.

Head clothed with griseous hairs; vertex convex, separated from the front by a deep transverse groove; encarpæ contiguous, pyriform, longer than broad, extending downwards as far as the insertion of the antennæ, interantennal space excavated; lower portion of clypeus transversely excavated; antennæ nearly as long as the body, moderately robust, filiform, the second joint short, the third nearly twice its length, the fourth and succeeding ones each equal in length to the third. Thorax broader than long; sides straight and nearly parallel from the base to beyond the middle, thence slightly rounded and obliquely converging towards the apex, the anterior angle obtuse, the hinder one acute; upper surface moderately convex, coarsely and strongly punctured; on the disk are two large, slightly raised smooth callosities, separated from each other by a narrow groove, but bounded at the base, apex, and the outer margin by a deep irregular sulcation; surface of disk more or less stained with piceous. Elytra rather broader than the thorax, parallel on the sides, transversely convex, not excavated below the basilar space; each elytron with twelve rows of large, deeply impressed punctures; the fourth interspace at its base, the fifth and ninth for nearly their whole length, confluent at their apices, strongly costate; upper portions of the tenth and eleventh interspaces subcostate.

This species may be known from *C. punctato-striata* by the pubescence on the upper surface of the body, by the strongly raised costæ on the elytra, and by the piceous colour of the head, under surface, and legs. The anterior acetabula in this insect are entirely closed.

Genus Platyxantha, *Baly*.

1. **Platyxantha clypeata.** Elongata, parallela, dorso deplanata, flava, nitida, thorace, mandibulis apice oculisque nigris; thorace transverso, lateribus e basi ad ultra medium rectis, paullo divergentibus, hinc apicem versus convergentibus; disco modice convexo, lævi, utrinque fovea parva, plus minusve distincta, impresso; elytris parallelis, ad latera convexis, dorso deplanatis, tenuiter confuse punctatis;

nigris, plaga magna communi, subquadrata, prope medium posita, flava. Long. 4 lin.

Var. A. Elytris flavis, basi et ad apicem piceo-tinctis.

Var. B. Elytris totis flavis.

Mas. Labro leviter incrassato, margine antico bilobato; clypei dimidio antico transversim excavato, margine antico medio bidentato; abdominis segmento anali trilobato, lobo intermedio fere plano, transversim quadrato.

Fem. Labro non incrassato, margine antico leviter sinuato; clypei disco antico non excavato, margine antico inermi; abdominis segmento anali apice extremo obtuso.

Hab. Andaman Islands.

Antennæ equal to the body in length, filiform in both sexes, rather more robust in the ♂; the basal joint slightly thickened, subclavate, the second very short, moniliform, the third and following ones each equal in length to the basal joint; maxillary palpi with the third joint obconic, not distinctly thickened in the ♂, the apical joint conic, acute; lower disk of the clypeus in the ♂ transversely concave, its anterior margin armed in the middle with two small acute teeth; lower disk in the ♀, its anterior border excepted, thickened, its lower edge unarmed. Thorax more than half as broad again as long; sides straight and diverging from the base to beyond the middle, thence rounded and converging towards the apex, the anterior and posterior angles each armed with an obtuse tooth; upper surface moderately convex, impunctate; disk impressed on each side with a small, more or less distinct fovea. Scutellum large, trigonate. Elytra broader than the thorax, parallel; upper surface convex on the sides, flattened along the suture, finely and irregularly punctured; interspaces (when seen under a deep lens) closely covered with minute punctures.

The above insect differs from the typical species in having the antennæ in the ♂ entirely filiform.

Genus ŒNIDEA, *Baly*.

1. **ŒNIDEA CÆRULEIPENNIS.** Oblongo-ovata, postice ampliata, rufo-testacea, nitida, antennis (articulo basali excepto) flavis, elytris metallico-cæruleis; thorace profunde transversim excavato; elytris oblongis, infra basin transversim depressis, tenuiter punctatis. Long. 3¾ lin.

Fem. Clypeo transversim sulcato.

Hab. Siam.

Antennæ very slender, filiform, equal to the body in length, the second joint very short, the third and fourth each equal in length to the first; front impressed just above the encarpæ with a deep fovea; encarpæ thickened, trigonate; clypeus concave, transversely sulcate. Thorax nearly twice as broad as long; sides straight and slightly diverging from the base to beyond the middle, thence obliquely rounded to the apex; anterior angles slightly produced, obliquely truncate, the hinder ones acute; upper surface convex, very minutely punctured; disk impressed with a broad transverse excavation, which terminates at some distance from the lateral margin, but is more deeply excavated at each end. Elytra oblong, convex, transversely excavated below the basilar space, and again obsoletely on the outer disk about its middle, the humeral callus thickened; surface finely punctured.

2. ŒNIDEA JACOBYI. **Anguste oblonga, postice paullo ampliata, convexa, nigra, nitida, labro antennisque flavis aut fulvis, pectore abdomineque rufo-piceis; thorace transversim sulcato, sulco utrinque fortiter foveolato; elytris oblongis, infra basin transversim excavatis, fere impunctatis, rufis, apice plus minusve nigris. Long. 4–4½ lin.**

Mas. **Clypeo transversim concavo; labro ampliato, concavo; abdominis segmento anali trilobato, lobo intermedio ad apicem leviter excavato.**

Fem. **Clypeo transversim sulcato; labro paullo incrassato.**

Var. A. Labro nigro aut nigro-piceo; elytris totis nigris.

Hab. Penang; Malacca; Borneo, Sarawak; Sumatra (*Wallace*).

Antennæ slender, equal to the body in length, and clothed with erect hairs in the ♂, rather shorter in the ♀; clypeus in the ♂ transversely trigonate, concave; labrum in the same sex dilated, rather deeply concave; clypeus in the ♀ deeply sulcate transversely, the labrum thickened. Thorax rather more than one half broader than long; sides straight and slightly diverging from the base to beyond the middle, thence converging to the apex; disk deeply excavated transversely, the sulcation terminating some distance within the lateral margin, more deeply excavated at each end. Elytra oblong, convex, transversely excavated below the basilar space, very minutely punctured, the punctures only visible under a lens.

3. **Œnidea pallipes**, *Fabr. Syst. El.* i. p. 479.—Subelongata, postice vix ampliata, rufo-testacea, nitida, oculis, elytrorum apice, abdomine pedibusque posticis (tarsis sordide fulvis exceptis) nigris; antennis labroque flavis; thorace transverso, disco sat profunde transversim sulcato, sulco utrinque magis fortiter excavato; elytris oblongis, infra basin leviter transversim depressis, tenuiter punctatis. Long. 3½ lin.

Mas. Facie inferiore profunde excavata, clypeo utrinque spinis duabus elongatis armato; labro ampliato, trilobato, lobis retrorsum spectantibus, duobus externis compressis, trigonatis, intermedio lineariformi; abdominis segmento anali utrinque emarginato.

Fem. Clypeo transversim concavo.

Hab. Sumatra (*Sir Stamford Raffles*).

Maxillary palpi in the ♂ with the third joint strongly thickened and enlarged; the fourth short, nearly buried in the third; clypeus in the ♂ deeply excavated, quadrispinose; the upper pair of spines acute, the lower two incurved, clothed with coarse hairs; labrum in the same sex thickened, its hinder margin trilobate, the outer lobes trigonate, acute, the middle one narrow, obtuse; clypeus in the ♀ transversely sulcate; antennæ filiform in both sexes. Thorax twice as broad as long; sides straight and diverging from the base nearly to the apex; disk finely but remotely punctured, transversely excavated, the sulcation more deeply impressed on each side, abbreviated before reaching the lateral margin. Elytra finely punctured.

This insect in v. Harold's Catalogue stands as a variety of *Haplosonyx sumatræ*.

Genus Cynorta, *Baly*.

1. **Cynorta ocellata.** Anguste elongata, parallela, flava, subnitida, oculis nigris; thorace quam longo paullo latiore, disco trifoveolato; elytris parallelis, longitudinaliter costatis, interspatiis subseriatim punctatis. Long. 2¼–2½ lin.

Mas. Facie inferiore profunde excavata, quadrituberculata, tuberculis duobus posticis conicis, duobus anticis compressis.

Hab. Malacca, Singapore (*Wallace*).

Eyes large, black; antennæ very slender, filiform, slightly exceeding the body in length; third joint equal in length to the first, slightly longer than the fourth; lower face deeply excavated in the ♂, armed with four tubercles—two, one on each side, immediately below the insertion of the antenna, conic, and two compressed, placed above the anterior margin of the clypeus, one on each side near the outer border. Thorax about one half broader than long; sides straight and slightly diverging from the base nearly to the apex; anterior angle slightly produced, obtuse, hinder angle armed with an obtuse lateral tooth; upper surface impressed with a large, shallow, trilobate fovea, which covers nearly the whole central disk. Elytra parallel, convex; each elytron with seven or eight distinct longitudinal costæ, their interspaces finely punctured.

I possess two specimens of this species, both belonging to the ♂ sex.

2. Cynorta apicipennis. **Subfiliformis, parallela, flava, oculis, elytrisque apice nigris; thorace quam longo vix latiore, disco leviter trifoveolato; elytris elevato-costatis, interspatiis punctatis. Long. 3 lin.**

Fem.? **Antennis longitudine corporem paullo superantibus; clypeo excavato, concavo.**

Hab. Sarawak (*Wallace*).

Narrowly elongate, parallel. Head strongly exserted; clypeus concave, smooth; maxillary palpi robust, the upper two joints conjointly ovate; antennæ slender, filiform, longer than the body. Thorax rather broader than long; sides slightly diverging and sinuate from the base to beyond the middle, thence converging towards the apex; upper surface impunctate, impressed with a large shallow trifid excavation, which covers a considerable portion of the surface. Elytra parallel, subcylindrical; each with eight or nine longitudinal costæ, their interspaces distinctly punctate. The abdomen in the only specimen before me is shrivelled, so that I am unable to decide with certainty as to its sex, but from the non-dilated basal joint of the anterior tarsus I believe it to be a female.

3. Cynorta facialis. **Subfiliformis, parallela, flava, oculis elytrisque apice nigris, abdominis apice nigro-piceo; thorace quam longo vix latiore, disco lævi, pone medium bifoveolato; elytris parallelis, leviter elevato-costatis, interspatiis distincte punctatis. Long. 2½ lin.**

Mas. **Clypei dimidio postico trigonato, flavo, medio fovea rotundata impresso; dimidio antico depresso, transversim concavo.**

Hab. Sarawak: a single specimen (*Wallace*).

Clypeus with its upper half not depressed, trigonate, its surface plane, impressed in the middle with a small round fovea; the lower half strongly depressed and separated from the upper portion by a sutural line, its surface transversely concave; antennæ filiform (the five upper joints in the solitary specimen under examination broken off). Thorax scarcely broader than long; sides slightly diverging and slightly sinuate from the base to beyond the middle, thence rounded and converging towards the apex; upper surface convex, smooth, impunctate, hinder disk impressed on each side with a large shallow fovea. Elytra parallel, subcylindrical; each with eight or nine slightly elevated costæ, the interspaces distinctly punctured.

The peculiar formation of the clypeus in this species closely resembles that of the same segment in *Cheiloxena*. As the peculiarity in the present instance is, however, probably only sexual, the removal of the insect from the genus in which I have placed it will not be justified until the other sex is known.

Genus MONOLEPTA, *Erichson*.

This natural group, founded by Erichson in 1843 on an African species, *M. pauperata*, has been subsequently divided by Chapuis, myself, and others into smaller generic groups, on characters derived chiefly from the open or closed state of the anterior acetabula and on the length of the epipleuræ. I have already stated my reasons for considering the first of these characters to be in a great measure unsatisfactory, and at any rate one not to be depended on by which to divide the *Galerucinæ* into primary sections. In *Monolepta* (taken as a whole) the lateral angles of the subbasal lobe of the prosternum are well developed, and in the great majority of species join the apices of the epimera to close the anterior acetabula; in some instances, however (*Luperodes alboplagiatus*, &c.), the epimera are abbreviated before reaching the sides of the lobe, and consequently the acetabula remain distinctly open; in a third set (*Ochralea*) the acetabula are found to be both closed and widely open in the same species, every intermediate stage occurring between the two extremes *.

The second, of great value when well defined and when really terminating at a given point, as in *Aulacophora* and other genera, fails in the present group for the following reason. In many species of *Monolepta* (including the typical one) the elytral epipleura gradually narrows towards the apex and extends backwards for nearly the whole length of the outer margin of the elytron; in others, the epipleura apparently ends at or about the middle of the margin; on examination, however, it will be seen that it does not terminate at that point, but although much narrowed extends to a greater or less extent along the hinder margin. The point at which the contraction takes place also varies greatly, so that I have thought it well to place all the species here described in *Monolepta.*

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* In *Luperodes præustus* and *L. discrepens*, two insects which differ from the rest of the genus in their oblong, not ovate form, the sides of the subbasal lobe are not produced, the lobe itself being either narrowly wedge-shaped or noduliform; the epimera are also much abbreviated, leaving the acetabula broadly open. These species should, I think, be retained in *Luperodes*.

1. **Monolepta hæmorrhoidalis**, *Fabr. Syst. El.* i. p. 490; *Oliv. Ent.* vi. p. 629, t. 3. fig. 33.—Anguste ovata, postice paullo ampliata, convexa, flava aut rufo-flava, nitida, antennarum articulis intermediis et apicalibus nigris aut nigro-piceis; thorace quam longo distincte latiore, convexo, lævi; elytris convexis, nigris, apice plus minusve sanguineis. Long. 2½–3 lin.

Mas. Elytro utroque ante medium fovea magna subrotundata, margine incrassata munito.

Hab. Australia; New Guinea, Mysol, Sulu Islands.

Antennæ filiform, the third joint about one half longer than the second; the three lower joints flavous, the eighth, ninth, and tenth, together with the basal portion of the eleventh, flavous; the upper portion of this last, together with the fourth to the seventh, black, or nigro-piceous. Thorax about one fourth broader than long; sides rounded, nearly straight and slightly diverging behind the middle, anterior angle armed with an obtuse tubercle; disk convex, smooth. Elytra oval, convex, slightly excavated below the basilar space in the ♀, minutely punctured; black, the apical portion to a greater or less extent bright sanguineous; each elytron in the ♂ is impressed with a large rotundate-ovate fovea placed on the anterior disk about halfway between the outer margin and the suture, and extending downwards to a little below the median line. Elytral epipleuræ extending below the middle. Anterior acetabula closed.

I possess two specimens of this species (both males) from Australia, the original locality given by Fabricius and Olivier, one, if not both, having formed part of the collection made during the voyage of the 'Coquille.' In these specimens the sanguineous coloration of the elytra is confined to the extreme apex, but in those from the Malay Archipelago, collected by Mr. Wallace, the red colour covers nearly the whole hinder disk, in some individuals even extending upwards beyond the median line.

2. **Monolepta Cumingii.** Anguste ovata, postice paullo ampliata, convexa, rufo flava, nitida, antennarum articulis intermediis ultimique apice, tibiis tarsisque nigris; thorace quam longo vix dimidio latiore, subcylindrico, disco paullo deplanato; elytris minute punctatis, nigris, utrisque macula parva basali dimidioque postico sanguineis. Long. 3 lin.

Mas. Elytro utroque callo subhumerali, hoc medio fovea rotundata, profunde impresso, instructo.

Hab. Philippine Islands, Manilla.

Encarpæ and lower face pale flavous. Antennæ filiform, the third joint twice the length of the second; the three lower ones rufo-flavous, the fourth to the seventh black; the four outer joints, the black apex of the apical one excepted, white. Thorax nearly one half broader than long; sides straight and very slightly diverging from the base to beyond the middle, thence slightly converging to the apex, the hinder angle acute, the anterior one slightly produced into an obtuse tubercle; disk subcylindrical, very minutely punctured, the puncturing only visible under a strong lens. Elytra convex, not excavated below the basilar space, finely and rather closely punctured. Each elytron in the ♂ with a large subhumeral callus, in the centre of which is a round fovea.

The narrow subcylindrical thorax in both sexes will at once separate the present species from its allies; the ♂ also may be at once known by the small size and different shape of the elytral fovea.

3. **Monolepta foveicollis.** Ovata, postice ampliata, convexa, flava, nitida, pedibus rufo-testaceis, antennarum articulis intermediis nigris; thorace transverso, disci medio transversim excavato; elytris tenuiter punctatis, nigris, apice sanguineis. Long. 3¼ lin.

Mas. Elytro utroque fovea magna ovata, disco externo ante medium posita, profunde impresso.

Hab. Batchian (*Wallace*): a single specimen.

Antennæ filiform, the third joint nearly one half longer than the second; the fourth to the seventh black, the rest flavous. Thorax nearly twice as broad as long; sides obliquely diverging from the base to the middle, thence rounded and converging to the apex, apical angle produced into a flattened obtuse tubercle; disk transversely convex, very minutely punctured, its middle third with a broad but shallow transverse depression, which is rather more deeply excavated on either side of the median line. Elytra convex, not excavated below the basilar space, minutely but not closely punctured; outer disk of each elytron in the ♂ with a large oval fovea, which commences at some little distance below the humeral callus and extends downwards as far as the middle line. Elytral epipleuræ extending for a short distance below the middle. Anterior acetabula closed.

4. MONOLEPTA TERMINATA, *Guér. Voy. de la Coquille*, ii. *Zool.* p. 149. —**Anguste ovata, postice paullo ampliata, convexa, rufo-testacea, nitida, tibiis tarsisque nigris aut nigro-piceis, antennis pallide flavis, articulo ultimo nigro; thorace quam longo latiore, convexo, lævi; elytris convexis, tenuiter punctatis; nigris, apice sanguineis. Long. 2½–3 lin.**

Mas. **Elytro utroque ante medium fovea magna subovata male definita, extus late sed leviter elevato-marginata, fundo leviter excavata, impresso.**

Hab. Java (*Guérin*), Borneo, Sumatra (*Wallace, Raffles*).

Antennæ filiform, the third joint one half longer than the second; pale flavous; the terminal and occasionally the upper half of the penultimate joints more or less stained with black. Thorax about one fourth broader than long; sides nearly straight and diverging from the base to the middle, thence rounded and converging towards the apex, the anterior angles thickened and produced, obtuse, hinder angles acute; hinder margin obtusely rounded; disk convex, smooth, impunctate. Elytra oval, convex, finely but not very closely punctured; on the anterior disk of each elytron in the ♂ (the only sex known to me) is a large, very shallow and ill-defined excavation, the outer and hinder edges of which are broadly but slightly thickened.

5. MONOLEPTA WALLACEI. **Late ovata, postice paullo ampliata convexa, sanguinea, nitida, tibiis tarsisque piceo tinctis, antennis pallide flavis, basi flavo-testaceis, articulis duobus ultimis nigris, abdomine flavo-rufo; thorace quam longo latiore, convexo, lævi; elytris convexis, minute punctatis, nigris, apice sanguineis. Long. 3–3½ lin.**

Mas. **Elytro utroque fovea magna subhumerali profunde excavata, limbo incrassata impresso.**

Hab. Celebes (*Wallace*).

Antennæ filiform, nearly equal to the body in length in the ♂, the third joint nearly twice as long as the second; pale flavous, the two lower joints flavo-testaceous, the two upper ones black. Thorax about one third broader than long; sides obliquely diverging and obsoletely sinuate from the base to the middle, thence rounded and converging to the apex, anterior angle produced into an obtuse tubercle, the hinder angle slightly produced, acute; disk convex, smooth, impunctate. Elytra convex, very minutely punctured; each elytron in the ♂ with a large ovate, deeply excavated fovea, placed on the outer disk immediately below the humeral callus and extending nearly to the middle, its entire margin strongly thickened.

I possess five specimens of the above insect collected by Mr. Wallace in Celebes: the broader form, together with the position of the elytral fovea, will at once separate it from the allied species; the elytral epipleuræ are also less abruptly narrowed below the middle than in the other similarly-coloured specific forms.

The five species described above are usually confounded in collections under the name of *hæmorrhoidalis* or *terminata*: the structural differences, however, at once separate them.

The following short Table will assist in distinguishing the species described above:—

1. Thorax impressed in the centre with a transverse fovea. *foveicollis.*

2. Thorax not transversely sulcate.
   - *a.* Thorax only slightly broader than long .. *Cumingii.*
   - *aa.* Thorax distinctly broader than long.
     - *b.* Thorax one half broader than long .... *hæmorrhoidalis.*
     - *bb.* Thorax one third broader than long.
       - *c.* Elytra oblong-ovate .... *terminata.*
       - *cc.* Elytra broadly ovate .... *Wallacei.*

6. **Monolepta verticalis.** Anguste ovata, postice paullo ampliata, convexa, nigro-picea, nitida, capite, antennis basi, thorace pedibusque anticis pallide flavis, pedibus posticis quatuor piceo-fulvis; capitis vertice fovea rotundata magna impresso; thorace transverso, convexo, lævi; elytris tenuiter punctatis, utrisque maculis duabus, una infra basin, altera prope apicem, flavis, ornatis. Long. 2 lin.

Var. A. Elytris pallide flavis, utrisque limbo fasciaque prope medium nigro-piceis, pedibus fulvis.

Var. B. Elytris fere totis flavis.

Hab. Malay Archipelago, Batchian, Aru and Sulu Islands (*Wallace*).

Vertex impunctate, impressed with a large round fovea; antennæ three fourths the length of the body, second joint short, the third slightly longer, four or five lower joints flavous or fulvous, the rest nigro-piceous. Thorax nearly twice as broad as long; sides rounded, the anterior and posterior angles produced, subacute; disk transversely convex, smooth, impunctate. Elytra oblong-ovate, very slightly dilated posteriorly, convex, not depressed below the basilar space, remotely impressed with fine punctures, their interspaces very minutely punctured. Abdominal segments in some specimens narrowly edged with flavous.

The outer margins of the flavous spots on the elytra are ill-defined, being more or less stained with piceous.

Genus PARAULACA.

Corpus **oblongum, convexum, postice paullo ampliatum.** ***Caput*** **exsertum;** ***antennis*** **filiformibus.** ***Thorax*** **transversus, dorso transversim sulcatus.** ***Elytra*** **convexa, confuse vel subseriato-punctata;** ***epipleuris*** **fere ad apicem extensis.** ***Pedes*** **simplices;** ***tibiis*** **apice spina brevi armatis;** ***unguiculis*** **appendiculatis.** ***Prosternum*** **inter coxas elevatum, basi non lobatum;** ***acetabulis*** **anticis apertis.**

Type *Paraulaca* (*Aulacophora*) *angulicollis*, Motsch.

The above genus differs solely from *Pseudocophora* in having appendiculate instead of bifid claws; occupying the same relative position to that genus that *Diacantha* does to *Aulacophora*. In both genera the prosternum is not lobed at its base, and the apices of the epimera are free, not closing the acetabula.

Genus PSEUDOCOPHORA, *Jacoby, Notes Leyd. Mus.* vi. p. 69.

The males of the present genus (so far as they are yet known) have a deep sutural fovea placed immediately below the basilar space on the elytra; this fovea, the edges of which are thickened, is armed with two or four raised tubercles or teeth; the number and shape of these teeth, taken in conjunction with the form and sculpture of the median lobe of the anal segment of the abdomen, afford good diagnostic characters for the separation of the males of the various species.

Specimens of all of the species described in the present paper are contained in my collection. *P. bicolor*, Jacoby, Proc. Zool. Soc. 1887, p. 111, from Ceylon, is unknown to me.

The following Table will assist the student in working out the species described below.

Table I. (*Males*).

A. Elytral fovea quadridentate.
a. Median lobe of the trilobate anal segment of the abdomen plane.
b. Hinder half of the elytra (the outer margin excepted) rufo-fulvous .... 1. *Buquetii.*
bb. Hinder half of elytra entirely black .... 2. *distincta.*
aa. Median lobe of anal segment of abdomen more or less concave.
b. Median lobe slightly concave .... 3. *Erichsoni.*
bb. Median lobe deeply excavated.
c. Elytral fovea with the anterior pair of teeth bifid. 4. *ambusta.*
cc. Elytral fovea with the anterior pair of teeth simple. 5. *Wallacei.*

B. Elytral fovea bidentate.
a. Median lobe of anal segment of abdomen plane.
b. Breast and abdomen black .... 6. *uniplagiata.*
bb. Breast and abdomen flavous .... 7. *flaveola.*
aa. Median lobe of anal segment concave.... 8. *brunnea.*

Table II. (*Females*).

A. Pygidium entire.
a. Apex of anal segment of abdomen deeply and narrowly incised .... 9. *pectoralis.*
aa. Apex of anal segment narrowly angulate-emarginate. 1. *Buquetii.*
aaa. Apex of anal segment broadly subangulate-emarginate. 3. *Erichsoni.*

B. Apical margin of pygidium more or less deeply emarginate.
  a. Apex of pygidium faintly emarginate .... 10. ***perplexa.***
  aa. Apex of pygidium trifid, the middle lobe elongate, its apical surface tuberculate .... 8. ***brunnea.***
  aaa. Apex of pygidium trifid, the middle lobe only slightly produced .... 4. ***ambusta.***

1. PSEUDOCOPHORA BUQUETII, *Guér.*

Galeruca Buquetii, *Guér. Voy. Coquille*, 1830, p. 143.

Oblongo-ovata, postice paullo ampliata, convexa, rufo-fulva aut fulva, pectore, abdomine pedibusque posticis quatuor nigris, antennis pallide flavis; thorace profunde transversim sulcato; elytris postice ampliatis, convexis, infra basin in ♀ leviter transversim depressis, distincte subseriato-punctatis, punctis pone medium minus fortiter impressis, confuse dispositis; rufis, basi late limboque externo nigris. Long. 2¾–3 lin.

Mas. Elytris infra basin fovea magna communi, fundo quadridentata instructis; abdominis segmento anali trilobato, lobo intermedio plano.

Fem. Abdominis segmento anali apice rotundato, medio abrupte angulato-emarginato.

Hab. Java.

Antennæ pale flavous; eyes prominent, black. Thorax nearly twice as broad as long; sides nearly straight and diverging from the base to beyond the middle, thence obliquely converging to the apex, anterior angle with an obtuse oblique tubercle; disk deeply sulcate transversely, the sulcation usually entire, rarely interrupted in the middle. Elytra oblong, dilated posteriorly, convex, slightly depressed in the ♀ below the basilar space, distinctly subseriate-punctate, the spaces between the rows of punctures more or less distinctly thickened; the punctures on the hinder disk finer and arranged without order. In the ♂ below the basilar space is a large common fovea, surrounded by a thickened margin, its surface armed with two pairs of teeth, the anterior pair thickened at the base, their apices deflexed and posteriorly produced, the hinder one flattened, truncate, and abruptly deflexed towards the suture; these teeth in some specimens are concolorous with the surface of the fovea, in others they are more or less fulvous; the anterior pair in some instances are obsoletely bifid.

2. Pseudocophora distincta. Late ovata, postice paullo ampliata, convexa, nitida, subtus nigra, pedibus anticis piceo-fulvis; supra piceo-fulva, antennis (basi exceptis) pallide flavis, elytrorum dimidio postico et (*in mare*) fovea subbasali nigris; thorace profunde transversim sulcato; elytris subseriatim punctatis. Long. 3 lin.

Mas. Elytris fovea magna subbasali, fundo quadridentata instructis; abdominis segmento anali trilobato, lobo intermedio plano.

Hab. Borneo (*Wallace*): a single specimen.

Antennæ slender, filiform, three fourths the length of the body, pale yellow, the two lower joints piceo-rufous. Thorax nearly twice as broad as long; sides obliquely diverging and slightly sinuate from the base to beyond the middle, thence obliquely converging to the apex; disk deeply excavated transversely just behind the middle, the sulcation interrupted on the median line. Elytra dilated from the base towards the apex, the latter broadly rounded; above convex, substriate-punctate on the anterior disk, irregularly punctured behind the middle; immediately below the basilar space in the male (the only sex known to me) is a large common fovea, surrounded by a thickened margin, its surface armed with four teeth, the anterior pair acute, their apices slightly deflexed, the hinder pair flattened, truncate and abruptly deflexed towards the suture.

This species is closely allied to *P. Buquetii*; in addition, however, to its different coloration, it is much broader than that insect.

3. Pseudocophora Erichsoni.

Pseudocophora Buquetii, *Jacoby*, *Notes Leyd. Mus.* vi. p. 69 (*pars*).

Ovata, postice ampliata, convexa, nigra, nitida, capite, thorace scutelloque fulvis aut rufo-fulvis, antennis pallide flavis, pedibus anticis piceis; thorace quam longo plus dimidio latiore, sat profunde transversim sulcato; elytris distincte subseriatim punctatis, punctis apicem versus confusis, fere obsoletis; flavo-fulvis, dimidio antico apiceque extremo nigris. Long. 3–3½ lin.

Mas. Elytris infra basin fovea magna communi quadridentata, dentibus duobus anticis obtusis, duobusque posticis conicis; abdominis segmento anali trilobato, lobo intermedio leviter concavo, apice rotundato.

Fem. Abdominis segmento anali apice emarginato.

Hab. Sumatra.

Antennæ filiform, the third and fourth joints nearly equal in length in both sexes, pale flavous, the basal joint fulvous, the

three apical ones stained with piceous. Thorax more than one half broader than long; sides very slightly diverging and sinuate from the base to beyond the middle, thence converging towards the apex, the hinder angles subacute, the anterior ones slightly produced, obtuse; disk transversely sulcate immediately behind the middle, the sulcation strongly impressed during its whole length. Elytra oblong, dilated posteriorly, convex, distinctly and rather strongly punctured, the puncturing nearly obsolete towards the apex; the punctures on the anterior half of the inner disk irregularly arranged in double rows.

The above species was confounded by Jacoby with *Buquetii*, Guér., on which he founded the genus; although similar in coloration to that insect, it is well separated by the structural characters in both sexes.

4. **Pseudocophora ambusta**, *Erichs. Nov. Act. Leopol. Carol.* xv. 1834, *Suppl.* i. p. 272.—Oblongo-ovata, postice paullo ampliata, convexa, fulva aut flava, antennis pallide flavis; pectore, abdomine, pedibus posticis quatuor elytrorumque limbo externo nigris; thorace transversim sulcato; elytris subseriato-punctatis, nigro-limbatis. Long. 2½ lin.

Mas. Elytris infra basin fovea magna, nigra, margine elevata, fundo quadridentata, dentibus duobus anticis bifidis; abdominis segmento anali trilobato, lobo intermedio concavo.

Fem. Abdominis pygidio apice trifido, lobo intermedio elongato tuberculo conico instructo; segmento anali medio concavo-emarginato.

Var. A, ♂. Elytrorum limbo externo nigro obsoleto.

Hab. Type, Luzon (*Erichson*); var. A, Celebes (*Wallace*).

Antennæ pale flavous, the third joint twice the length of the second, rather longer than the fourth. Thorax twice as broad as long; sides slightly diverging and rather strongly sinuate from the base to beyond the middle, thence obliquely converging to the apex, the anterior angles slightly excurved; disk transversely sulcate, the sulcation interrupted in the middle part of its course. Elytra similar in form to those of *P. Buquetii*; their surface less strongly punctured, the subcostate interspaces being absent. The males may be known by the anterior pair of teeth on the subbasal fovea being distinctly bifid, not single as in the other species of the genus; the hinder pair are formed as in *P. Buquetii*.

5. **Pseudocophora Wallacei.** Oblongo-ovata, postice paullo ampliata, convexa, fulva, nitida, pectore pedibusque nigris, antennis nigro-piceis; thorace transversim sulcato; elytris oblongis, postice paullo ampliatis, convexis, subseriatim punctatis, punctis apicem versus confusis. Long. 2¾ lin.

Mas. Elytris infra basin fovea magna, elevato-marginata, fundo quadridentata, dentibus duobus anticis simplicibus; abdominis segmento anali trilobato, lobo intermedio basi concavo-excavato.

Hab. Bouru (*Wallace*).

Antennæ nigro-piceous. Thorax nearly twice as broad as long; sides slightly converging and slightly sinuate from the base to far beyond the middle, thence slightly converging to the apex, the anterior angle acute; disk deeply sulcate transversely, the sulcation less deeply excavated on the median line. Elytra convex, subseriate-punctate anteriorly, irregularly punctured behind the middle; elytral fovea in the ♂ (the only sex known to me) quadridentate; the anterior pair of teeth simple, the posterior pair compressed, incurved.

6. **Pseudocophora uniplagiata,** *Jacoby, Notes Leyden Mus.* vi. p. 214.—Oblongo-ovata, postice paullo ampliata, convexa, fulva, nitida, pectore, abdomine pedibusque posticis quatuor elytrorumque fovea subbasali nigris, antennis pallide flavis; thorace profunde transversim sulcato; elytris distincte subseriato, pone medium confuse punctatis. Long. 2½-3 lin.

Mas. Elytris infra basin fovea magna communi nigra, elevato-marginata, antice bituberculata instructis; abdominis segmento anali trilobato, lobo intermedio oblongo, profunde excavato.

Hab. Sumatra; Siam.

Similar to *P. brunnea*, the elytra more strongly punctured, the anal segment of abdomen of an entirely different form.

7. **Pseudocophora flaveola.** Ovata, postice ampliata, flava, nitida, thorace transversim sulcato; elytris tenuiter punctatis. Long. 2¼ lin.

Mas. Elytris infra basin fovea magna communi antice bituberculata, tuberculis obtusis, contiguis; abdominis segmento anali trilobato, lobo intermedio plano, apice late rotundato.

Hab. Andaman Islands.

Antennæ filiform; eyes black. Thorax transverse; sides from the base to far beyond the middle nearly straight, diverging, then obliquely converging towards the apex: disk transversely sulcate, nearly impunctate. Elytra broadly oblong, dilated posteriorly, convex, impressed below the base in the ♂ with a large common fovea, the anterior margin of which is furnished with two obtuse tubercles, placed one on each sutural margin immediately below the scutellum; general surface of elytra minutely and remotely punctured.

The ♀ of this species is unknown to me.

8. Pseudocophora brunnea, *Baly, Journn. Linn. Soc.* vol. xx. p. 26. Oblongo-ovata, postice paullo ampliata, convexa, fulva, nitida, pectore, abdomine pedibusque posticis quatuor nigris; elytrorum limbo externo et (*in mare*) fovea magna subbasali nigris; thorace profunde transversim sulcato; elytris substriato pone medium confuse punctatis. Long. 3 lin.

Mas. Elytris infra basin fovea magna communi, elevato-marginata, antice bituberculata instructis; abdominis apice trilobato, lobo intermedio plano.

Fem. Pygidii apice trifido, lobo intermedio elongato, tuberculo acuto instructo; segmento anali late emarginato.

Hab. Malacca; Celebes.

Thorax nearly twice as broad as long; sides nearly straight and very slightly diverging from the base to beyond the middle, thence slightly converging to the apex; disk deeply sulcate transversely, the sulcation rather less deeply impressed on the median line. Elytra sculptured as in *P. Wallacei*, differing in the number of teeth on the subbasal fovea; in the present species, as in the preceding two, the anterior margin of the fovea is armed with two obtuse tubercles, the hinder pair being obsolete.

The male of the present species differs from the same sex of *P. uniplagiata*, Jac., in the form and sculpturing of the anal segment of the abdomen; in *P. brunnea* the median lobe is subquadrate and plane, in *P. uniplagiata* it is oblong and deeply concave. The coloration of the insect closely resembles that of the typical form of *P. ambusta*, Erichs.

Females of which the Males are unknown to me.

9. Pseudocophora pectoralis. Ovata, postice ampliata, convexa, flava, nitida, pectore abdomineque (hujus apice excepto) nigris; thorace transverso, disco transversim sulcato; elytris convexis, infra basin non excavatis, distincte punctatis, punctis hic illic subseriatim dispositis. Long. 2¼ lin.

Fem. Abdominis segmento anali apice profunde emarginato.

Hab. Assam: a single specimen.

Antennæ filiform; eyes black. Thorax nearly twice as broad as long; sides nearly straight, diverging from the base to beyond the middle, thence obliquely converging towards the apex; disk smooth, nearly impunctate, impressed just behind the middle with a transverse groove. Elytra rather strongly punctured.

10. **Pseudocophora perplexa.** Ovata, postice paullo ampliata, convexa, piceo-fulva, nitida, metapectore, abdomine pedibusque posticis quatuor nigris, antennis, tibiis tarsisque anticis pallide flavis; thorace sat profunde transversim sulcato; elytris tenuiter punctatis. Long. 3¼ lin.

Fem. Abdominis pygidio apice leviter angulato-emarginato; segmento anali apice obtuso, obsolete sinuato.

Hab. Philippine Islands.

Antennæ yellowish white. Thorax nearly twice as broad as long; sides slightly diverging and sinuate from the base to beyond the middle, thence converging towards the apex, the hinder angle acute, the anterior slightly produced, obtuse; upper surface transversely convex, deeply sulcate transversely immediately behind the middle, the sulcation nearly as deeply impressed in its median portion as on its sides; disk smooth, impressed with a few distant punctures on the sides. Elytra oblong, slightly dilated posteriorly, convex, finely but distinctly punctured.

The present insect closely resembles the same sex of *P. ambusta*, var. A; but the entirely different form of the pygidium in the two species at once separates them.

Genus Aulacophora, *Chevr.*

The first six species here described have simple antennæ in both sexes; in the last eight the antennæ in the males have the third to the sixth joints compressed, and more or less thickened and dilated; the females of this section appear to be much rarer in collections than the other sex, and only in a few cases are known to me. The following Table gives the differential characters of the males of this latter group:—

TABLE.

I. Vertex and front on each side with an elevated ridge.
  1. Frontal ridges transverse .... 8. *palliata.*
  2. Frontal ridges oblique.
    a. Elytra black...................... 7. *orientalis.*
    aa. Elytra flavous, with black markings.. 11. *bipartita.*
  3. Frontal ridges perpendicular.
    b. Elytra black .... 9. *frontalis.*
    bb. Elytra flavous, with black markings.. 10. *fraudulenta.*

II. Vertex and front without elevated ridges.
  1. Elytra flavous, with black markings.
    a. Antennæ with their outer half black .... 12. *Olivieri.*
    aa. Antennæ flavous .... 13. *occipitalis.*
  2. Elytra black .... 14. *lævifrons.*

1. AULACOPHORA ANALIS, *Weber.*

Galeruca analis, *Weber, Obs. Ent.* p. 55, 1810; *Fabr. Syst. El.* i. p. 482.

Subelongata, postice paullo ampliata, flava, nitida, thorace transverso, vix pone medium transversim sulcato; elytris infra basin obsolete depressis, tenuissime punctatis, opacis, utrisque plaga magna humerali, ad basin et ad marginem exteriorem adfixa, alteraque pone medium, subrotundata, sæpe ad marginem extensa, nigris aut cæruleo-nigris. Long. 3½–4 lin.

A. "Abdominis ano et margine, tibiis tarsisque nigrescentibus."

B. Pygidio, abdomine, tibiis tarsisque nigris.

C. Abdomine pygidioque flavis, hoc sæpe nigro-piceo tincto, tibiis tarsisque ut in B.

Mas. Abdominis segmento anali trilobato, lobo intermedio quadrato-oblongo, disco leviter concavo, medio elevato-vittato.

Fem. Abdominis segmento anali apice obtuso, medio obsolete emarginato.

Hab. Sumatra, Celebes, Sulu Islands, Philippines.

Antennæ slender, filiform in both sexes; the third joint rather longer than any of the following ones. Thorax rather more than one half broader than long; sides nearly straight and parallel, sometimes slightly diverging from the base to the middle, very slightly converging towards the apex anteriorly; disk smooth, impunctate, impressed immediately behind the middle with a deep transverse groove. Elytra narrowly oblong, slightly dilated posteriorly; convex, very faintly excavated on the suture below the basilar space, opaque, very minutely punctured.

A. analis, Weber, agrees very closely in general form with *A. bicolor* of the same author; the structural differences, however, in the anal segments of the abdomen in both sexes, although slight, are apparently constant, and sufficient to separate the two insects; *A. analis* is also smaller than the other species.

2. **Aulacophora Wilsoni.** Anguste oblonga, postice ampliata, convexa, nitida, subtus nigra, prothorace pedibusque anticis flavis, his plus minusve piceo tinctis; supra flava, antennis (basi exceptis) scutelloque nigris; thorace transversim sulcato, sulco fere recto, medio magis fortiter excavato; elytris tenuiter punctatis. Long. 3½ lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio profunde concavo; pygidii apice obtuso.

Fem. Abdominis segmento anali apice concavo-emarginato, incissuræ margine leviter deflexo.

Hab. Australia, Melbourne.

Antennæ moderately robust, filiform, the first joint, together with the basal portions of the second and third, fulvous; labrum nigro-piceous; eyes black. Thorax with its sides nearly straight and only very slightly diverging from the base to beyond the middle, thence obliquely converging towards the apex; disk transversely sulcate, the sulcation straight, rather more deeply excavated in the middle. Elytra oblong, dilated posteriorly, convex, obsoletely depressed below the basilar space, the latter sometimes obsoletely thickened; the surface minutely punctured.

In addition to other structural differences, the sculpturing of the thorax will distinguish the above insect from *A. nigroscutata*, which species it closely resembles in coloration.

3. **Aulacophora Perroudi.** Elongato-oblonga, postice paullo ampliata, convexa, flava, nitida, antennis (basi exceptis), pectore abdomineque nigris, tibiis tarsisque nigro-piceis; thorace transversim sulcato, sulco medio fere obsoleto; elytris infra basin leviter excavatis, tenuiter sed distincte punctatis. Long. 4 lin.

Fem. Abdominis segmento anali rotundato, utrinque sinuato.

Hab. New Caledonia.

Eyes and antennæ black, the latter with the two lower joints flavous. Thorax twice as broad as long; sides diverging and slightly sinuate from the base to beyond the middle, thence rounded and converging to the apex; lateral margin strongly reflexed; disk transversely sulcate, the sulcation strongly excavated on each side, nearly obsolete on the middle disk. Elytra narrowly oblong, slightly dilated posteriorly, slightly but distinctly excavated below the basilar space, finely punctured.

I only know a single specimen (a ♀); it is at once to be known from its allies by the interrupted sulcation on the thorax. This species is the one to which, in a note to the second Table in my former paper on *Aulacophora*, I have alluded to as *palustris*, Perroud; that species belongs (as I have subsequently ascertained) to the genus *Monolepta*.

4. **Aulacophora argyrogaster**, *Montrouz. Ann. Soc. Ent. France*, 1861, p. 299.—Anguste oblonga, postice paullo ampliata, convexa, sordide flava, subnitida; ore, antennis (basi exceptis) corporeque inferiore (pedibus anticis anoque exceptis) nigris aut nigro-piceis, abdomine sparse argenteo-sericeo; thorace sat profunde transversim sulcato; elytris subopacis, tenuiter punctatis. Long. 3½ lin.

Mas. Abdominis segmento anali trilobato, lobo intermedio profunde concavo; pygidii apice extremo obtuso.

Fem. Abdominis segmento anali late concavo-emarginato; pygidii apice acuto.

Hab. New Caledonia.

Antennæ filiform, basal joint in the ♂ slightly thickened and compressed, clavate; the third, fourth, and fifth nearly equal in length in both sexes. Thorax nearly twice as broad as long; sides nearly parallel and slightly sinuate from the base to beyond the middle, thence rounded and converging towards the apex; upper surface very minutely punctured, the puncturing coarser on the sides; disk impressed across the middle with a deep transverse sulcation, which in the ♂ is broader and more deeply excavated in the middle, the anterior margin of the dilated portion being thickened and obsoletely bituberculate; in the ♀ the anterior margin of the sulcation (which is of nearly equal depth and breadth throughout) is not thickened nor tuberculate. Elytra oblong, not distinctly excavated below the basilar space, minutely punctured.

The peculiar sculpture of the thorax in the ♂ and the acute apex of the pygidium and sculpture of the anal segment of the abdomen in the ♀, conjointly with the coloration of the under surface, will separate this species from its congeners.

5. Aulacophora austro-caledonica, *Montrouz. Ann. Soc. Ent. France*, 1861, p. 299.—Subelongata, postice paullo ampliata, convexa, flava, nitida, verticis maculis duabus, pectore abdomineque nigris, hoc basi et ad latera pallide piceo; thorace transversim sulcato, sulco fere recto; elytris nitidis, utrisque plagis magnis duabus, una basali ad suturam abbreviata, altera pone medium positis, nigris. Long. 2¼–3 lin.

Mas. Antennis filiformibus, robustis; abdominis segmento anali trilobato, lobo intermedio oblongo, profunde concavo.

Fem. Abdominis segmento anali lateribus rectis, oblique convergentibus, apice extremo obtuso.

Hab. New Caledonia, Balade.

Vertex with two large black patches, separated in the middle by a narrow flavous line; antennæ filiform in both sexes, more robust in the ♂ than in the other sex, the joints slightly stained with piceous. Thorax more than one half broader than long; its sides sinuate and slightly diverging from the base to the middle, slightly produced immediately before the latter, thence rounded and converging to the apex; disk impressed across the middle with a deep transverse groove. Elytra oblong, very slightly dilated posteriorly, minutely punctured.

This species closely resembles *A. occipitalis* in the coloration of its head and underside; the antennæ, however, of the ♂ of *austro-caledonica* are simple, not dilated as described by Mr. Jacoby (Annal. del Mus. Civic. Stor. Nat. Gen. 1886, vol. iv. p. 53); the male assigned by him to the present insect belongs to another species nearly allied to, if not identical with, *A. occipitalis*. I possess both sexes of *austro-caledonica* from New Caledonia.

6. Aulacophora Lewisii, *Baly, Journ. Linn. Soc.* vol. xx. p. 24.—*Mas.* Antennis robustis, ad apicem paullo attenuatis, abdomine nigro aut piceo-nigro, apice extremo piceo-fulvo; segmento anali trilobato, lobo intermedio longitudinaliter sulcato.

Fem. Abdominis segmento anali apice utrinque leviter sinuato.

Var. A. Corpore subtus toto glabro.

Hab. India and China (type and var. A); Malay Archipelago (var. A).

The specimen from which I originally drew up the diagnosis of this species (a ♀) had been carded, and the apex of the abdomen was so obscured by gum that I described it as entire; since then I have had the opportunity of examining many specimens of both sexes, and find that the apex of the female anal segment is distinctly, although slightly, sinuate on each side.

7. **Aulacophora orientalis**, *Hornst. Schrift. Berl. Ges.* viii. 1788, p. 5, t. 1. fig. 3.—Anguste oblonga, postice paullo ampliata, convexa, rufo-fulva, nitida, antennis flavis, oculis elytrisque nigris; thorace transverso, disco transversim sulcato, elytris convexis, infra basin leviter transversim depressis, tenuiter punctatis. Long. 3 lin.

Mas. Capitis vertice utrinque creta elevata, oblique posita, instructo; antennarum articulis tertio, quarto quintoque incrassatis, difformibus; abdominis segmento anali lobo intermedio oblongo-quadrato, plano aut leviter concavo.

Var. A, ♂. Antennis, tibiis tarsisque nigro-piceis.

Hab. Java, New Guinea, Dorey, Ceram, Gilolo; var. A, New Guinea (*Wallace*).

Vertex in the ♂ with an elevated ridge, placed obliquely on each side just above the eye and running inwards to nearly meet its fellow in the median line; antennæ in the ♂ with the basal joint thickened, slightly curved, clavate, its outer edge subcarinate; second joint small, the third thickened and subclavate, its apex truncate; the fourth and fifth also thickened, dilated laterally, subtrigonate, each shorter than the third; the apex of the fourth obliquely truncate, its anterior and outer angle produced, acute or subacute; the fifth with its outer surface deeply concave, the anterior angles of the concavity acute. Thorax nearly twice as broad as long; sides nearly straight and parallel from the base to beyond the middle; upper surface transversely sulcate immediately behind the middle, rather coarsely punctured on the sides in front. Elytra slightly convex, faintly depressed below the basilar space, finely punctured.

8. **Aulacophora palliata**, *Schaller, Abhandl. Hall. Ges.* i. 1783, p. 279; *Fabr. Mant.* i. 1787, p. 87; *Oliv. Ent.* vi. p. 625, t. 2. fig. 25, *a–b*.—Anguste oblonga, postice ampliata, convexa, fulvo-rufa,

nitida, elytris nigris; thorace transversim sulcato, ad latera punctato. Long. 3¼ lin.

Mas. **Capitis vertice utrinque creta crassa transversa instructo; antennarum articulis tertio, quarto quintoque ampliatis, difformibus; abdominis segmento anali lobo intermedio quadrato-oblongo, leviter concavo.**

Hab. India; Malay Archipelago.

Front on each side in the ♂ with a strongly thickened transverse ridge; antennæ in the same sex with the basal joint thickened, slightly curved, the second very small, the third and two following ones thickened and laterally dilated, the third slightly longer than broad, trigonate, its outer and upper angle slightly produced, acute, the fourth very slightly shorter than the third, quadrangular, its upper and outer angle broadly and obliquely truncate; the fifth shorter than either of the preceding two, subtrigonate, its outer surface longitudinally concave, the outer and upper angle of the concavity bidentate. Thorax nearly twice as broad as long; sides nearly straight and parallel from the base to beyond the middle, thence obliquely converging towards the apex; disk transversely sulcate just below the middle, coarsely punctured on the sides in front. Elytra oblong, slightly dilated posteriorly; convex, slightly impressed below the basilar space, finely punctured.

9. **AULACOPHORA FRONTALIS.** **Anguste oblonga, postice paullo ampliata, flavo-fulva, nitida, antennis pallide flavis, elytris nigris; thorace transversim sulcato, remote punctato, punctis ad latera subcrebre dispositis; elytris infra basin transversim excavatis, tenuiter punctatis. Long. 2½ lin.**

Mas. **Capitis fronte bisulcato, utrinque inter sulcum et oculum tuberculo oblongo, dorso compresso et intus curvato, instructo; antennarum articulis tertio, quarto quintoque ampliatis; abdominis segmento anali trilobato, lobo intermedio quadrato-oblongo, leviter concavo.**

Hab. Borneo, Sarawak (*Wallace*).

Front and vertex longitudinally bisulcate; placed longitudinally on each side between the sulcation and the eye is an oblong protuberance, the upper edge of which is compressed and incurved; front separated from the encarpæ by a deep transverse groove; antennæ in the ♂ with the basal joint thickened, slightly curved, its lower surface deeply emarginate, the third and two following joints thickened and dilated, trigonate, the third nearly twice as broad as long, its outer edge strongly compressed, carinate, the fourth and fifth nearly equal in length, each rather shorter than the third, the upper and outer angle of the fifth emarginate, bidentate. Thorax rather more than one half broader than long; sides nearly straight from the base to the middle, thence slightly rounded and converging towards the apex; disk transversely sulcate immediately behind the middle, very distantly and minutely punctured, the puncturing rather closer on the sides. Elytra oblong, dilated posteriorly, convex, transversely excavated below the basilar space, finely punctured.

The three similarly coloured species described above are readily separated in the male sex by the position and form of the frontal tubercles. The females are not known to me.

10. Aulacophora fraudulenta, *Jacoby, Annal. del Museo Civ. di Storia Natur. di Genova*, vol. iv. p. 52 (1886).—**Anguste oblonga, postice ampliata, convexa, flava, nitida, antennis extrorsum infuscatis; oculis, metasterno elytrisque nigris, his fascia lata prope medium flava. Long. 3 lin.**

Mas. **Capitis fronte, utrinque prope oculum tuberculo oblongo magno, longitudinaliter posito, instructo; antennarum articulis tertio, quarto quintoque ampliatis, trigonatis; abdominis segmento anali trilobato, lobo intermedio oblongo-quadrato, apice bilobato, disco leviter longitudinaliter concavo.**

Hab. New Guinea.

Front on each side in the ♂ with a strongly raised oblong tubercle, placed longitudinally close to the inner margin of the eye, apex of the tuberosity torulose, slightly incurved; antennæ in the same sex with the basal joint thickened, its outer edge concave-emarginate; the third and two following joints dilated, trigonate, the third and fifth equal in length and breadth, the fourth longer than either of the two others, but less broadly dilated; in the specimen before me, sent by Mr. Jacoby, the outer half of the antennæ is stained with fuscous (the author describes these organs as entirely flavous)*. Thorax nearly twice as broad as long; sides nearly straight and slightly diverging from the base to beyond the middle, thence rounded and converging towards the apex; disk impressed just behind the middle with a transverse sulcation; surface finely and remotely punctured, the punctures more crowded on the sides in front. Elytra convex, faintly excavated on the suture below the basilar space, finely punctured.

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* The ♀ of this insect is unknown to me, the specimen sent by Mr. Jacoby as belonging to that sex proving to be the ♂ of a similarly coloured species having simple antennæ.

11. AULACOPHORA BIPARTITA. Anguste oblongo-ovata, postice paullo ampliata, convexa, flava, subnitida, vertice, oculis, thoracis dimidio antico, metapectore abdomineque nigris; thorace transversim sulcato, sulco medio minus fortiter impresso, disco interdum ante basin maculis parvis male definitis nigro-piceis, instructo; elytris oblongis, postice paullo ampliatis, subcrebre punctatis, obsolete longitudinaliter sulcatis; utrisque plagis duabus magnis, una basali, unaque vix pone medium, nigris. Long. 3 lin.

Mas. Capitis vertice utrinque creta oblique posita instructo; antennarum articulis tertio, quarto quintoque compressis, triangulariter dilatatis; abdominis segmento anali trilobato, lobo intermedio concavo.

Fem. Antennis simplicibus; abdominis segmento anali apice obtuso.

Var. A, ♀. Capite toto flavo, thorace utrinque ante medium plaga magna nigra instructo; elytrorum plaga infra medium obsoleta.

Hab. Flores; Sarawak (*Wallace*). Var. A, Java.

Clypeus in the ♂ with a narrow, rather strongly raised longitudinal ridge; front just above the encarpæ with a deeply impressed fovea; obliquely placed on each side just within the eye is a broad slightly raised elongated ridge; eyes in the ♂ large, prominent. Antennæ with the third and following two joints compressed, triangularly dilated, the third less broadly so than the two others; third and fourth equal in length, the fifth rather shorter. Thorax transverse; sides slightly diverging and sinuate from the base to beyond the middle, thence obliquely rounded and converging to the apex; upper surface minutely punctured, impressed immediately behind the middle with a deep transverse groove. Elytra oblong, slightly dilated towards the apex; convex, distinctly and rather closely punctured; disk of each elytron with five or six faint longitudinal sulcations.

12. AULACOPHORA OLIVIERI.

Galeruca analis, *Oliv. Ent.* vi.

Oblongo-ovata, convexa, flava, nitida, labro, antennis (basi exceptis), mesosterno, abdominis apice, tibiis tarsisque nigro-piceis aut nigris; thorace quam longo fere duplo latiore, transversim sulcato, sulco medio minus fortiter impresso; elytris tenuiter punctatis, utrisque plaga magna basali, ad suturam abbreviata, altera pone medium, ad marginem plerumque adfixa, apiceque nigris. Long. 3–3¼ lin.

Mas. **Antennarum articulis tertio, quarto quintoque incrassatis; abdominis segmento anali trilobato, lobo intermedio longitudinaliter sulcato.**

Fem. **Antennis filiformibus; abdominis segmento anali apice rotundato.**

Hab. Australia, Hunter's River, Rockhampton, Paroo River.

Front impressed immediately above the encarpæ with a small fovea; antennæ robust, the third, fourth, and fifth joints in the ♂ thickened, the third nearly twice as long as broad, obconic, the fourth and fifth each shorter than the third, laterally dilated, trigonate; antennæ in the ♀ simple, filiform; the five lower joints in the ♂, the three or four basal ones in the ♀, flavous or fulvous, more or less stained with piceous, the remaining joints in each sex nigro-piceous or black. Thorax nearly twice as broad as long; sides slightly diverging and slightly sinuate from the base to just beyond the middle, thence rounded and converging to the apex; upper surface remotely and minutely punctured, transversely sulcate immediately behind the middle, the sulcation rather less deeply impressed on the middle disk. Elytra oblong, slightly dilated posteriorly, convex, minutely punctured, the basilar space obsoletely thickened. Tibiæ and tarsi black, the basal portion of the former sometimes flavous.

This species usually stands in collections as *A. analis*, Weber; it is very constant in pattern and coloration, and differs from the author's description of *analis* in the dark antennæ, in the black apices of the elytra, and in the similarly coloured mesosternum. Its locality is also entirely different, all the specimens that I have seen having been brought from Australia; whereas Weber gives Sumatra as the habitat of his insect.

13. AULACOPHORA OCCIPITALIS. **Subelongata, postice paullo ampliata, convexa, flava, nitida, oculis, verticis plagis duabus, pectore abdomineque nigris; thorace prope medium transversim sulcato;**

elytris infra basin leviter transversim excavatis, utrisque plaga basali subquadrata, ad suturam et ad marginem abbreviata alteraque pone medium subrotundata, nigris. Long. 3 lin.

Mas. **Antennarum articulis tertio, quarto quintoque compressis et dilatatis; abdominis segmento anali trilobato, lobo intermedio oblongo, profunde concavo.**

Hab. New Guinea, Dorey; Bouru (*Wallace*).

Vertex with two large black patches, divided in the median line by a flavous line; antennæ with the third, fourth, and fifth joints compressed and dilated in the ♂; the third twice as long as broad, narrowly cuneiform, the fourth shorter and more strongly dilated than the third, trigonate, its antero-external angle produced, very acute; the fifth still shorter than the fourth, subtrigonate. Thorax about one half as broad again as long; sides sinuate, subparallel, slightly produced just beyond the middle, thence obliquely converging towards the apex; disk impressed across the middle with a deep sulcation. Elytra faintly excavated below the basilar space, nitidous.

The ♂ of *A. occipitalis* differs from the same sex of *A. fraudulenta*, Jac., in the absence of the frontal tubercles, and in the different length and shape of the dilated joints of the antennæ, also in the black patches on the vertex, and in the black breast and abdomen. The females of both species are unknown to me.

14. AULACOPHORA LÆVIFRONS. Anguste oblonga, postice ampliata, rufo-fulva, nitida, antennis flavis, tibiis (basi exceptis) tarsisque piceis aut nigro-piceis, elytris tenuiter punctatis, nigris; thorace vix pone medium transversim sulcato, sulco profunde impresso, paullo infra marginem lateralem abbreviato. Long. 3 lin.

Mas. **Capitis vertice non tuberculato; antennarum articulis tertio, quarto quintoque incrassatis et ampliatis, difformibus.**

Fem. **Antennis filiformibus, abdominis segmento anali apice obtuse truncato.**

Var. A, ♀. Tibiis tarsisque rufo-fulvis.

Hab. Java; Singapore (*Wallace*).

Vertex and front smooth, not tuberculate, the latter impressed just above the encarpæ with a deep fovea; antennæ in the ♂ with the basal joint slightly thickened, subclavate, the third joint slightly thickened, obconic; the fourth equal in length to the preceding one, rather strongly thickened, slightly compressed, noduliform,

the fifth shorter than either of the preceding two, broader than long, trigonate, its antero-external angle slightly produced, acute. Thorax more than one half as broad again as long; sides nearly straight and diverging from the base to beyond the middle, thence obliquely converging towards the apex; disk deeply transversely sulcate immediately behind the middle, the sulcation more deeply impressed on each side, abbreviated just within the lateral margin; surface very finely and remotely punctured, the punctures more crowded on the sides in front. Elytra oblong, dilated posteriorly; convex, transversely excavated below the basilar space, finely punctured.

The abdomen of the ♂ in the only specimen known to me is not fully developed; I am therefore unable to give the form of the median lobe of the anal segment of the abdomen.

Genus LEPTOXENA.

Corpus angustum, elongatum, convexum. *Caput* exsertum; ***antennis*** filiformibus, extrorsum leviter incrassatis et paullo compressis; ***oculis*** integris; ***palpis maxillaribus*** ovatis, articulo ultimo acuto. *Thorax* transversus, transversim convexus. *Elytra* subcylindrica; ***epipleuris*** a basi ad angulum posticum extensis. *Pedes* robusti; ***tibiis*** inermibus; ***unguiculis*** bifidis, dente interno breviore; ***femoribus tibiisque*** posticis in ♂ incrassatis; ***tarsis*** posticis articulo basali ad duos sequentes fere æquilongo. *Prosternum* basi non lobatum; ***acetabulis*** anticis fere clausis, ***epimeris*** anticis cum antepectoris margine postico intime connexis.

Leptoxena is allied to *Galerucella*, but may be separated from that genus by its narrower form, thickened hinder legs in the ♂, and by the anterior epimera being continuous with the hinder border of the antepectus for their whole length, whereas in *Galerucella* their apices are free.

LEPTOXENA EXIMEA. Anguste elongata, parallela, transversim convexa, fusco-fulva, subnitida, thoracis punctis duobus, antennis (basi exceptis) abdomineque nigris; thorace transverso, lateribus late rotundatis, antice sinuatis; disco nitido, leviter transversim convexo, utrinque leviter excavato; elytris fere parallelis, subcylindricis, infra basin non excavatis, fortiter et irregulariter punctatis, vittis nonnullis, leviter elevatis instructis, interstitiis reticulatis. Long. 5 lin.

Mas. **Abdominis segmento anali apice angulatim inciso; femoribus tibiisque posticis incrassatis, his extrorsum ante apicem sinuatis.**

Fem. **Abdominis segmento anali integro; pedibus posticis non incrassatis.**

Hab. Andaman Islands (Calcutta Museum and my own collection).

Head strongly exserted, vertex swollen; antennæ with the first joint curved, clavate, the second and third short, nearly equal, the fourth as long as the preceding two united, these three joints cylindrical, the fifth and following ones compressed, the five upper ones being thickened and moderately dilated; the six upper joints black. Thorax nearly three times as broad as long; sides broadly rounded, sinuate before the middle, the hinder angles obsolete; disk transversely convex, slightly but broadly depressed and excavated on each side; nitidous, the central third, the median line excepted, rather closely punctured, sides impunctate; on each side, but at some distance from the outer margin, is a round black or nigropiceous spot. Scutellum clothed with sericeous hairs. Elytra rather broader than the thorax, parallel on the sides; upper surface transversely convex, not depressed or excavated below the basilar space; closely and strongly punctured, the interspaces subelevate-reticulate; each elytron with seven or eight slightly raised longitudinal costæ, those on the outer disk more distant and less defined.

I possess both sexes of this species from the Andaman Islands; I have also received it, without locality, from the Calcutta Museum.

List of Species.

Charidea (n. g.) *punctato-striata* (Motsch.)	Japan.
—— *Fortunei*	Northern China.
Platyxantha clypeata	Andaman Islands.
Œnidea cæruleipennis	Siam.
—— *Jacobyi*	Borneo.
—— *pallipes* (Fabr.)...........................	Sumatra.
Cynorta ocellata	Malacca.
—— *apicipennis*	Sarawak.
—— *facialis*	,,
Monolepta hæmorrhoidalis (Fabr.)	Australia; New Guinea.
—— *Cumingii*	Manilla.

Monolepta foveicollis	Batchian.
—— *terminata*, Guér.	Java.
—— *Wallacei*	Celebes.
—— *verticalis*	Batchian.
Paraulaca (n. g.) *angulicollis* (Motsch.).	
Pseudocophora Buquetii (Guér.)	Java.
—— *distincta*	Borneo.
—— *Erichsoni*	Sumatra.
—— *ambusta* (Erichs.)	Luzon.
—— *Wallacei*	Bouru.
—— *uniplagiata*, Jacoby	Sumatra.
—— *flaveola*	Andaman Islands.
—— *brunnea*	Malacca.
—— *pectoralis*	Assam.
—— *perplexa*	Manilla.
Aulacophora analis (Weber)	Sumatra.
—— *Wilsoni*	Melbourne.
—— *Perroudi*	N. Caledonia.
—— *argyrogaster* (Montrouzier)	,,
—— *austro-caledonica* (Montrouzier)	,,
—— *Lewisii*	China, &c.
—— *orientalis* (Hornst.)	Java.
—— *palliata* (Schaller)	India.
—— *frontalis*	Borneo.
—— *fraudulenta*, Jacoby	N. Guinea.
—— *bipartita*	Flores.
—— *Olivieri*	Australia.
—— *occipitalis*	N. Guinea.
—— *lævifrons*	Java.
Leptoxena (n. g.) *eximea*	Andaman Islands.

Divergent Evolution through Cumulative Segregation. By Rev. JOHN THOMAS GULICK. (Communicated by ALFRED RUSSEL WALLACE, F.L.S.)

[Read 15th December, 1887.]

INTRODUCTION.

IN my study of Sandwich-Island terrestrial mollusks my attention was early arrested by the fact that wide diversity of allied species occurs within the limits of a single island, and in districts which present essentially the same environment. As my observations extended, I became more and more impressed with the improbability that these divergences had been caused by differences in the environment. It was not easy to prove that sexual selection had no influence; but, owing to the very low grade of intelligence possessed by the creatures, it seemed impossible that the form and colouring of the shells should be the result of any such process. I was therefore led to search for some other cause of divergent transformation, the diversity of whose action is not dependent on differences in nature external to the organism.

I found strong proof that there must be some such principle, not only in the many examples of divergence under uniform activities in the environment, but in the fact that the degrees of divergence between nearly allied forms are roughly measured by the number of miles by which they are separated, and in the fact that this correspondence between the ratios of distance and the ratios of divergence is not perceptibly disturbed by passing over the crest of the island into a region where the rainfall is much heavier, and still further in the fact that the average size of the areas occupied by the species of any group varies, as we pass from group to group, according as the habits of the group are more or less favourable to migration. I perceived that these facts could all be harmonized by assuming that there is some cause of divergence more constant and potent than differences in nature external to the organism; and that the influence of this cause was roughly measured by the time and degree of separation.

During the summer of 1872 I prepared two papers in which these facts and opinions were presented. One of these, entitled "The Variation of Species as related to their Geographical Distribution, illustrated by the Achatinellinæ," was published in

'Nature' for July 18, 1872; the other, entitled "Diversity of Evolution under one Set of External Conditions," after being read before the British Association for the Advancement of Science in August 1872, was, through the kindness of Mr. Alfred Wallace, brought before the Linnean Society, and was finally published in the Linnean Society's Journal, Zoology, vol. xi. pp. 496–505.

In the former paper I used the following words in calling attention to the impossibility of explaining the origin and distribution of these forms by Natural Selection. "Whether we call the different forms species or varieties, the same questions are suggested as to how they have arisen and as to how they have been distributed in their several localities. In answering these questions, we find it difficult to point to any of those active causes of accumulated variation, classed by Darwin as Natural Selection. . . . There is no reason to doubt that some varieties less fitted to survive have disappeared; but it does not follow that the 'Survival of the Fittest' (those best fitted when compared with those dying prematurely, but equally fitted when compared with each other) is the determining cause which has led to these three species being separated from each other in adjoining valleys. *The 'Survival of the Fittest' still leaves a problem concerning the distribution of those equally fitted.* It cannot be shown that the 'Survival of the Fittest' is at variance with the survival, under one set of external circumstances, of varieties differing more and more widely from each other in each successive generation. The case of the species under consideration does not seem to be one in which difference of environment has been the occasion of different forms being preserved in the different localities. It is rather one in which varieties resulting from some other cause, though equally fitted to survive in each of the localities, have been distributed according to their affinities in separate localities."

In the latter paper I raised the following questions concerning Natural Selection. "The terms 'Natural Selection' and 'Survival of the Fittest' . . . . imply that there are variations that may be accumulated according to the differing demands of external conditions. What, then, is the effect of these variations when the external conditions remain the same? Or, can it be shown that there is no change in organisms that is not the result of change in external conditions? Again, if the initiation of change in the organism is through change in the environment, . . .

does the change expend itself in producing from each species just one new species completely fitted to the conditions, *or may it produce from one stock many that are equally fitted?*" (p. 497). In answering these questions I called "attention to the variation and distribution of terrestrial mollusks, more especially those found on the Sandwich Islands," and gave what seemed to me strong reasons for believing that "*The evolution of these different forms cannot be attributed to difference in their external conditions.* . . . If we would account for the difference and the limited distribution of these allied forms on the hypothesis of evolution from one original species, *it seems to me necessary to suppose two conditions, Separation and Variation.* I regard *Separation* as a condition of the species, and not of surrounding nature, because it is a state of division in the stock which *does not necessarily imply any external barriers, or even the occupation of separate districts. This may be illustrated by the separation between the castes of India, or between different genera occupying the same locality.* . . . We must suppose that they [the diverging forms] must possess an inherent tendency to variation so strong that *all that is necessary to secure a divergence of types* in the descendants of one stock *is to prevent*, through a series of generations, *their intermingling* with each other to any great degree" (pp. 498–499). I also called attention to the fact that some forms of Natural Selection must "prevent variation and give a wider diffusion to forms that would otherwise be limited in their range and variable in their type. Natural Selection is as efficient in producing permanence of type in some cases as in accelerating variation in other cases" (p. 504). On page 499 I pointed out the law that "The area occupied by any species must vary directly as its power and opportunity for migration, and inversely as its power of [divergent] variation." And on page 505 I gave a brief summary of my reasons for believing that "*Separation without a difference of external circumstances is a condition sufficient to ensure . . . divergence in type.*"

Subsequent investigation has led to the development of my theory, with a fuller discussion of the causes and laws that are revealed in these phenomena. In an article published in 'The Chrysanthemum' (Yokohama and London, Trübner & Co.), January 1883, I state my belief "that the quality, the diversity, and the rapidity of the variation depend chiefly upon the nature of the organism; and that while the nature of the external conditions has power to winnow out whatever forms are least fitted to survive, *there will usually remain a number of varieties equally fitted to survive*; and that *through* the *law of segregation* constantly operating in species distributed over considerable areas, *these varieties continue to diverge* both in form and in habits till separate species are fully established, though the conditions are the same throughout the whole area occupied by the diverging forms." The conclusion reached was, that "The theory that diversity of Natural Selection is, like variation, an essential factor in producing diversity of species, is untenable. On the contrary, we find that diversity of Natural Selection is not necessary to diversity of evolution, nor uniformity of Natural Selection to uniformity of evolution; but while *variation and separation are the essential factors in diversity*, and intercrossing and unity of descent the essential agents in uniformity of *evolution*, Natural Selection may be an important ally on either side."

In an article on "Evolution in the Organic World," published in 'The Chinese Recorder' (Shanghai), July 1885, I use the following language:—"We see what Natural Selection cannot explain by considering the nature of the process. The survival of the fittest results in the separate breeding of the fittest, and therefore in the increasing fitness of successive generations of survivors; *but how can it account for the division of the survivors of one stock, occupying one country, into forms differing more and more widely from each other? To explain such a result we must find some other law. I am prepared to show that there is such a law rising out of the very nature of organic activities, a law of Segregation, bringing together those similarly endowed, and separating them from those differently endowed.*"

Without Variation there can be no Segregate Breeding; and without Segregate Breeding and Heredity there can be no accumulation of divergent variations resulting in the formation of races and species. In producing divergent evolution, the causes of Variation and Heredity are therefore as important as the causes of Segregate Breeding; and though I pass them by in my present discussion, I trust it will not be attributed to an underestimate of their importance. Though I do not stop to discuss the causes of variation, my reasoning rests on the observed fact that in every department of the organic world variation is found, and that in the vast majority of cases, if not absolutely in all, the diversities to which any freely intergenerating group of organisms is subject follow the general law of "Frequency of Deviation from an Average." As this is a law according to which half of the members of the intergenerating group are above and half below the average in relation to any character, there must often occur simultaneous variation of several individuals in some character which tends to produce Segregate Breeding. The reality and importance of this law is not at all dependent on the reality of any of the theories of heredity and variation that are now being discussed. Whatever may be the causes that produce variation, whether they depend entirely upon changes in external conditions, or are chiefly due to changing activities in the organism and the hereditary effects of acquired characters, or are, as Weismann maintains, the direct result of sexual reproduction which never transmits acquired characters,—in any and every case this law of Deviation from an Average remains undisturbed, and is recognized as an important factor in the present paper. It therefore cannot be urged that the theory here advanced assumes simultaneous variation without any ground for making such an assumption; nor can it be said that it rests on the incredible assumption that chance variation of very rare kinds will be duplicated at one time and place, and will represent both sexes.

Moritz Wagner first discussed what he calls "The law of the migration of organisms" in a paper read before the Royal Academy of Sciences at Munich, in March 1868; but my attention was not called to it till after the reading of my paper before the British Association in August 1872. In a fuller paper entitled "The Darwinian Theory and the Law of the Migration of Organisms," an English translation of which was published by Edward Stanford (London, 1873), the same author maintains that "the constant tendency of individuals to wander from the station of their species is absolutely necessary for the formation of races and species" (p. 4). "The migration of organisms and their colonization are, according to my conviction, a necessary condition of natural selection" (p. 5). On pp. 66 and 67 he expands the same statement, and objects to Darwin's view "that on many large tracts all individuals of the same species have become gradually changed." Again, he contends that "Transformation is everywhere and always dependent on isolation in order to have lasting effect. Without separation from the home of the species, this wonderful capacity would be completely neutralized" (p. 74). "Natural Selection is not in itself an unconditional necessity, but is dependent on migration and geographical isolation during a long period, together with altered conditions of life" (p. 57). "Where there is no migration, that is where no isolated colony is founded, natural selection cannot take place" (p. 59).

A comparison of his paper with my two papers published in 1872, already referred to, will show several fundamental differences in the two theories. He maintains that:—

(1) The separation of a few individuals from the rest of the species is absolutely necessary for the operation of Natural Selection, and therefore for any transformation of the species, no matter how great the change of conditions may be in the original home of the species.

(2) Migration and geographical barriers are the only effectual causes, independent of human action, by which a few individuals can be separated from the rest of the species, and are, therefore, necessary to the transformation of species.

(3) Exposure to a new form of Natural Selection is a necessary condition for any transformation of a species.

(4) Difference of external conditions is necessary to difference of Natural Selection, and therefore necessary to any transformation of species.

(5) Geographical isolation and altered conditions of life are necessary conditions for Natural Selection, as that is for the modification of species.

(6) The separation of which he speaks is the entering of a few individuals into a new territory, where the conditions are different from those in the old habitat, and where the body of the species fail of reaching them.

My chief positions were the following, in strong contrast with the foregoing:—

(1) Separate generation is a necessary condition for divergent evolution; but not for the transformation of all the survivors of a species in one way.

(2) "Separation does not necessarily imply any external barriers, or even the occupation of separate districts."

(3) Diversity of Natural Selection is not necessary to diversity of evolution.

(4) Difference of external conditions is not necessary to diversity of evolution.

(5) "Separation and Variation," that is, Variation not overwhelmed by crossing, "is all that is necessary to secure a divergence of types in the descendants of one stock," though external conditions remain the same, and though the Separation is other than geographical.

(6) The Separation of which I speak is anything, in the species or in the environment, that divides the species into two or more sections that do not freely intercross, whether the different sections remain in the original home or enter new and dissimilar environments.

Though these propositions were very briefly and imperfectly presented, I am not aware that any better statement of the facts of Segregation had been previously published.

The present paper is the result of a long continued endeavour to understand the relations in which this factor stands to Natural Selection and the other causes that co-operate in producing divergent evolution; and though my work has been done under the great disadvantage of entire separation from libraries, and from other workers in similar lines, I trust it may contribute something towards the elucidation of the subject. In expanding my theory I have been unable to make any use of the positions taken in Moritz Wagner's paper, as they seem to me very extreme and far removed from the facts of nature. The two theories correspond chiefly in that they discuss the relation of Separation to the transformation of species; while the explanations given of the nature, causes, and effects of Separation widely differ. I am informed that my paper on "Diversity of Evolution under One Set of External Conditions" was translated and circulated in Germany; but whether it had any effect in modifying Wagner's theory, I have not the means of knowing.

I have recently discovered that the principle of Segregate Breeding, which I have found to be of such importance in the evolution of species, is allied to the law of Segregation propounded by Spencer in his 'First Principles.' By direct consideration of the conditions that have been found necessary for the development of divergent races of domestic plants and animals, I have discovered Segregate Breeding as a necessary condition for divergent evolution; and by direct observation on the propagation of plants and animals under natural conditions, I have discovered Cumulative Segregation as a constant result fron certain forms of activity in the organism when dealing with a complex environment; it is therefore with special pleasure that I observe that a law of very similar import may be derived by a wholly different method from the general laws of action and reaction in the physical world. It should, however, be noticed that in the brief references made to the subject in Spencer's 'Principles of Biology'* it is assumed that "Increasingly-definite distinctions among variations are produced wherever there occur definitely-distinguished sets of conditions to which the varieties are respectively subject," and only where these occur; for "Vital actions remain constant so long as the external actions to which they correspond remain constant;" and no reference is anywhere made to the principle that whatever causes sexual separation between dissimilar members of one family, race, or species tends not only to perpetuate, but to increase their dissimilarity in the succeeding generations. The view maintained in the following paper is, I believe, in better accord with the fundamental principle that "Unlike units of an aggregate are sorted into their kinds and parted when uniformly subject to the same incident forces,"† as is also the teaching of Spencer's 'Principles of Biology' in one passage; for I have recently discovered that in a single paragraph of this work it is maintained that, while exposed to the same external conditions, the members of the same species may be increasingly differentiated, "until at length the divergence of constitutions and modes of life become great enough to lead to segregation of the varieties."‡ If the segregation had been introduced as a necessary condition without which the divergence of families and races could not take place, the position taken in this paragraph would have been essentially the same as the one I have adopted. In the next section, however, he abandons the position, using the following words:—"Through the process of differentiation and integration which of necessity brings together, or keeps together, like individuals, and separates unlike ones from them, *there must nevertheless be maintained a tolerably uniform species, so long as there continues a tolerably uniform set of conditions in which it may exist.*" [The italics are mine.]

I trust my endeavour to contribute something toward the development of the theory of divergent evolution will not be attributed to any lack of appreciation of what has already been accomplished. The propounders of a doctrine which has profoundly influenced every department of modern thought need no praise from me; but as their theory is confessedly incomplete, and as one of the leaders in the movement has called attention to the need of a rediscussion of the fundamental factors of evolution, I offer my suggestions and amendments after prolonged and careful study.

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* Compare §§ 91, 156, 169, 170.

† See Spencer's 'First Principles,' § 166, near the end; also a fuller statement in § 169.

‡ See § 90.

Physiological Selection and Segregate Fecundity.

The abstract of Mr. Romanes's paper on "Physiological Selection," given in 'Nature' August 5th, 12th, and 19th, 1886, did not come into my hands till the following January, when my theory of Divergent Evolution through Cumulative Segregation, which had been gradually developing since the publication of my paper on "Diversity of Evolution under One Set of External Conditions," was for the most part written out in its present form. Since then, and with reference to the discussion on Physiological Selection, I have worked out the algebraic formulas given in the last chapter, and have introduced explanations of the same; but at the same time I have removed several chapters in which the principle of selection was discussed at length, and have endeavoured to bring the whole within a compass that would allow of its being published by some scientific society. In order to attain this end, I reserve for another occasion a discussion of the principles of Intensive Segregation, under which name I class the different ways in which other principles combine with Segregation in producing Divergent Evolution.

It was my intention to bring together examples of the different forms of Segregation discussed, that they might be published with the theoretical part; but the large number of pages found necessary for even the briefest presentation of the principles involved, and the fact that Mr. Romanes's paper has appeared relating to some of the same problems, leads me to present the results of my studies without further delay. The facts on which large portions of my theory rest are of the most familiar kind, and no additional light would be gained though their numbers were multiplied a hundredfold. Indeed one of the marked features of my theory is that in its chief outlines it rests on facts that are universally acknowledged. The aim of the theory is to show the connection of these facts with divergent evolution.

Though many divergences appear in our method of treating the subject, the fundamental theory underlying my Segregate Fecundity and Mr. Romanes's Physiological Selection seems to be very similar, if not the same. The most important differences I have noticed are, (1) that he seems to regard mutual sterility as sufficient to account for the separate propagation of species and varieties thus characterized, without calling in the aid of any other form of segregation, while I regard it as a Negative form of Segregation that would result in the general destruction of all life if not associated with what I call Positive forms of Segregation; and (2) that he maintains that "Physiological selection is almost exclusively a theory of the origin of species, seeing that it can but very rarely have had anything to do with the formation of genera, and can never have had anything at all to do with the formation of families, order, or classes. Hence, the evidence which we have of the evolutionary influence of physiological selection, unlike that which we have of the evolutionary influence of natural selection, is confined within the limits of specific distinctions," * while I maintain that Segregation of some form is a necessary condition for all divergent evolution, and that in fact Segregate Fecundity in many cases prevents the intercrossing of divergent forms that, though descended from a common stock, now belong to different families and orders.

The first of these differences, though of considerable importance, is, I think, due to the method of presentation, rather than to any fundamental discrepancy in the theories. The Positive forms of Segregation are, I judge, assumed to be present, though their co-operation is not distinctly recognized as a necessary condition for the breeding of forms that are mutually sterile.

I must, however, confess that I do not see how to reconcile his statement that "Physiological selection can never have had anything at all to do with the formation of families, orders, or classes" with what I believe to be the facts concerning Segregate Fecundity; and if physiological selection is to be understood as including Seasonal and perhaps other forms of Segregation, this passage seems to be still more opposed to the principles of divergent evolution as I understand them. He certainly could not have intended to say that mutual fertility between allied

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* Linn. Soc. Journ., Zoology, vol. xix. p. 396.

genera not otherwise segregated would not have stood in the way of their becoming different families, and that therefore mutual sterility has had nothing to do with their continued divergence; still he seems to have failed to perceive the important influence this principle must have had on the divergent evolution of the higher groups of organisms.

The correspondences in the two papers are notwithstanding more remarkable than the differences. Of these, the most conspicuous is the use of the word Segregation to express the principle under consideration.* As I have already pointed out, I used this word for the same purpose in an article in the 'Chrysanthemum,' published in January 1883; and again in the 'Chinese Recorder' for July 1885, where I spoke of the "Law of Segregation rising out of the very nature of organic activities, bringing together those similarly endowed," and causing "the division of the survivors of one stock, occupying one country, into forms differing more and more widely from each other."

I trust that my discussion of the various forms of Segregation, both Negative and Positive, though presented in so condensed a form, will throw light on the subject of the mutual sterility of species; and that in other ways my presentation of the subject will contribute something, not only to the theory of Physiological *Segregation*, but to other branches of the general theory of evolution.

I should here acknowledge (what will, I think, be manifest on every page of my paper) that my obligations to Darwin and Wallace are far greater than are indicated by quotations and references.

I very much regret that I have failed of obtaining a copy of 'Evolution without Natural Selection,' by Charles Dixon; but, from his letter in 'Nature,' vol. xxxiii. p. 100, I see that he maintains "That isolation can preserve a non-beneficial variation as effectually as natural selection can preserve a beneficial variation." He does not there refer to the fact, which I emphasize, that all divergence of a permanent character, whether beneficial or non-beneficial, is dependent on Segeneration either Separative or Segregative.

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* See paper on "Physiological Selection," Linn. Soc. Journ., Zoology, vol. xix. pp. 354, 356, 391, 395.

PRELIMINARY DEFINITIONS.

Believing that great obscurity has often been introduced into the discussion of biological subjects by the use of terms of uncertain import, I have endeavoured to obtain greater precision by giving definitions of the terms I have introduced; and for the sake of indicating what words are thus used with special and definite meanings, they have been distinguished by capitals. A few of these definitions are here given, and others will be given in the body of the paper.

An Intergenerant, or *Intergenerating Group*, is a group of individuals so situated and so endowed that they freely cross with each other.

Segeneration, or *Independent Generation*. In harmony with the fundamental doctrines of evolution, I assume that each species was at one time a single intergenerant; but we find that many species are now divided into two or more intergenerants, between which there is little or no intercrossing. This state of freedom from crossing I call Segeneration. Segeneration is of two kinds, Separate Generation and Segregate Generation.

Separate Generation, or *Separation*, is the indiscriminate division of a species into groups that are prevented from freely crossing with each other.

Segregate Generation, or *Segregation*, is the intergeneration of similar forms and the prevention of intergeneration between dissimilar forms.

Select Generation, or *Selection*, is the partial or complete exclusion of certain forms from the opportunity to propagate, while others succeed in propagating. The generation of any form is *select* with reference to the non-generation of forms that fail of propagating, and *segregate* with reference to the generation of forms that propagate successfully, but separately.

Adaptational Selection is exclusive generation that depends upon superior adaptation either to the environment or to other members of the same species.

Natural Selection is the exclusive generation of those better fitted to the natural environment, resulting from the failure to generate of those less fitted.

Artificial Selection is the exclusive generation of those better fitted to the rational environment.

Reflexive Selection is the exclusive generation of those better fitted to the relations in which the members of the same species stand to each other. Sexual, Social, and Institutional Selection are forms of Reflexive Selection.

The Environment is nature lying outside of the Intergenerant. The influence of the Environment is the sum of the influences that fall upon the members of an Intergenerant, exclusive of their influence upon each other. The environment of an intergenerant includes members of the same species, only when these members are so near that they exert an influence through competition or otherwise, while at the same time they are so far differentiated that they do not intercross; in other words, the members of the same species can mutually belong to the environment, only when they have acquired some of the characteristics of independent species. The same environment extends as far as the activities that affect or may affect the species extend without undergoing change.

Change in the Environment is change in the external activities affecting the species.

Entering a new Environment is change in the territorial distribution of the species, bringing either all or a portion of its members within the reach of new influences. This may also be called *Change of Environment.*

Change in the Organism, whether producing new adaptations to the environment or not, should be carefully distinguished from both of the above described changes.

Change of Relations to the Environment may be produced by Change in the Environment, or by Entering a new Environment, or by Change in the Organism.

As great confusion has been occasioned by the terms "Conditions of Life" and "External conditions" being used, sometimes for activities outside of the species under consideration, and sometimes for those within the species (as for example the influence upon the seed produced by its position in the capsule), I have tried to avoid their use.

Monotypic Evolution is any transformation of a species that does not destroy its unity of type.

Polytypic Evolution or *Divergent Evolution* is any transformation of a species in which different types appear in different sections.

CHAPTER I.

THE EFFECTS OF SELECTION AND INDEPENDENT GENERATION CONTRASTED.

In as far as any theory of evolution fails of giving an explanation of divergence of character, in so far it fails of explaining the origin of species. This is the crucial test which must decide the strength or weakness of every theory that is brought forward to account for the derivation of many species from one original species. A satisfactory theory will not only point out the conditions on which divergence depends, but will show that these conditions are the natural result of causes that are already recognized by science as having influence in the organic world, or that are now shown to have such influence.

In the present chapter I shall present some reasons for believing that neither "Natural Selection," nor "Sexual Selection," nor "the Advantage of Divergence of Character," nor "Difference of External Conditions," nor all these taken together, nor any form of Selection that may be hereafter discovered, is sufficient to account for Divergence of Character, but that another factor of equal if not superior importance must be recognized. In subsequent chapters I shall try to trace the causes on which this additional factor depends, and to indicate as far as possible the laws and relations under which they appear.

DIVERGENT EVOLUTION NOT EXPLAINED BY NATURAL SELECTION.

Natural Selection is the exclusive generation of certain forms through the failure to live and propagate of other kinds that are less adapted to the environment.

In the case of the breeder, no selection avails anything that does not result in some degree of exclusion. In the case of natural selection, where we are not considering ineffectual intentions, the selection is measured by the exclusion. Where there is no exclusion, there is no selection, and where the exclusion is great the selection is severe. Moreover, it is self-evident that there can be no crossing between the best fitted that survive and propagate, and the least fitted that perish without propagating. To this extent, therefore, the prevention of crossing is complete. And further, it is evident that those whose meagre fitness gives them but little opportunity for propagating will have a correspondingly diminished opportunity for crossing with the best fitted; and so on through the different grades of fitness, the power to affect the next generation through having a share in propagating will measure the power to affect the progeny of the best fitted by crossing with them. It therefore follows that the freest crossing of the fittest is with the fittest.

Natural Selection therefore proves to be *a process in which the fittest are prevented from crossing with the less fitted through the exclusion of the less fitted*, in proportion to their lack of fitness. Through the premature death of the least fitted, and the inferior propagation of the less fitted, there arises a continual prevention of crossing between the less fitted and the better fitted; and without this separation the transforming influence of the laws of organic life would have no power to operate. As Darwin has pointed out, the results produced by this removal of the less fitted and separate propagation of the better fitted, closely correspond with those produced by the breeder, who kills off the less desirable individuals of his stock before they have opportunity to breed. The selection of the breeder avails nothing unless it leads to the determining of the kind that shall breed; and this he cannot accomplish without preventing free crossing with those that he does not desire. He must use some method to secure the separate breeding of the form that he desires to propagate. We therefore find in both Natural and Artificial Selection the same fundamental method. In either case, the kind that is to propagate is determined by the selection, and those that are not to propagate are in some way excluded. The process may therefore be called the exclusive breeding of certain kinds; and *Natural Selection* may be defined as *the exclusive breeding of those better adapted to the environment.*

But if from one stock of horses we wish to develop two distinct breeds, one of which shall excel in fleetness, and the other in strength for carrying or drawing burdens, the result will not be gained by simply preventing all that are inferior in strength or fleetness from breeding. By this process, which is the Exclusive Breeding of the desired kinds, we should obtain one breed with fair powers of strength and fleetness; but the highest results in either respect would not be gained. *Such experiments show that the Exclusive Breeding of other than average forms causes Monotypic Evolution, and that to secure Divergent or Polytypic Evolution some other principle must be introduced.*

In the case of Natural Selection, the separation it introduces is between the living and the dead, between the successful and the unsuccessful. In other words, Natural Selection is the exclusion of all the forms that through lack of adaptation to the environment fail of leaving progeny, and therefore in the exclusive generation of the forms that through better adaptation to the environment are better able to propagate. *Variation with the Natural Selection of other than average forms may therefore account for the transformation of an ancient species into a series of successive species* the last of which may now exist in full force; *but without the aid of Segeneration it will by no means account for the divergent evolution of any one of these species into a family of coexisting species.*

As I have just shown, Natural Selection is the exclusive generation of those better fitted to the environment; and it tends to the modification of species simply through the generation of the better fitted forms, while they are prevented from crossing with the less fitted, which fail of propagating through their lack of fitness. Now from the very nature of this process, which results from the success and failure of individuals in appropriating the resources of the environment, it follows that it cannot be the cause of separation between the successful competitors, and therefore any divergence of character that arises between the different groups of the successful cannot be attributed to Natural Selection. Natural Selection explains the prevention of crossing between the fitted and the unfitted, and shows how the successive generations of a species may gradually depart from the original type, becoming in time a different species; but *it cannot explain the divergences that arise between those that have, by the fact of successful propagation, proved their fitness.* It depends on superiority of adaptation to the environment, and tends to produce increasing adaptation; but *divergent kinds of adaptation are not necessary conditions for it, and it cannot be the cause of increasing divergence between the incipient kinds that otherwise arise.*

DIVERGENT EVOLUTION NOT EXPLAINED BY "THE ADVANTAGE OF DIVERGENCE OF CHARACTER."

Two sections of the 4th chapter of the 'Origin of Species' are given to the discussion of the "principle of benefit being derived from divergence of character," which it is maintained "will generally lead to the most different or divergent variations being preserved and accumulated by natural selection." Now it cannot be doubted that ability to appropriate unused resources would be an advantage to any members of a community pressed for food; but I do not see how the divergence that would enable them to appropriate, for example, a new kind of food can be accumulated while free crossing continues; and Natural Selection cannot prevent the free crossing of competitors who leave progeny.

Having found that the evolution of the fitted is secured through the prevention of crossing between the better fitted and the less fitted, can we believe that the evolution of a special race, regularly transmitting a special kind of fitness, can be realized without any prevention of crossing with other races that have no power to transmit that special kind of fitness? Can we suppose that any advantage, derived from new powers that prevent severe competition with kindred, can be permanently transmitted through succeeding generations to one small section of the species while there is free crossing equally distributed between all the families of the species? Is it not apparent that the terms of this supposition are inconsistent with the fundamental laws of heredity? Does not inheritance follow the lines of consanguinity; and when consanguinity is widely diffused, can inheritance be closely limited? When there is free crossing between the families of one species will not any peculiarity that appears in one family either be neutralized by crosses with families possessing the opposite quality, or being preserved by natural selection, while the opposite quality is gradually excluded, will not the new quality gradually extend to all the branches of the species; so that, in this way or in that, increasing divergence of form will be prevented?

If the advantage of freedom from competition in any given variation depends on the possession, in some degree, of new adaptations to unappropriated resources, there must be some cause that favours the breeding together of those thus specially endowed, and interferes in some degree with their crossing with other variations, or, failing of this, the special advantage will in succeeding generations be lost. As some degree of Independent Generation is necessary for the continuance of the advantage, it is evident that the same condition is necessary for the accumulation through Natural Selection of the powers on which the advantage depends. *The advantage of divergence of character cannot be retained by those that fail to retain the divergent character; and divergent character cannot be retained by those that are constantly crossing with other kinds; and the prevention of free crossing between those that are equally successful is in no way secured by Natural Selection.*

NATURAL SELECTION WITH GREAT DIFFERENCE IN EXTERNAL CONDITIONS NOT SUFFICIENT TO EXPLAIN DIVERGENT EVOLUTION.

The insufficiency of Natural Selection without Segeneration to account for divergent evolution in an area where the external conditions are nearly uniform may be admitted by some who will claim that the case is quite otherwise when a species ranges freely over an area in which it is subjected to strongly contrasted conditions. It may be claimed that Diversity of Natural Selection resulting from a great difference in external nature is sufficient to account for divergent evolution without any Segeneration.

In the discussion of this subject, important light can be gained by referring to the experience of the breeder. This experience, in as far as it relates to the subject of Separation in the production of divergent breeds, may be arranged under three heads. 1st. Diversity of Selection without Separation. 2nd. Separation without Diversity of Selection. 3rd. Separation more or less complete with Diversity of Selection.

As the full discussion of these points is impossible here, and as there is probably but little difference of opinion in regard to what the results would be, I shall content myself with a simple statement of what I believe the experience of breeders shows. Difference in the standards of Selection without Separation can avail nothing in creating divergence of types; while Separation without difference in the standards of Selection will avail something, though food and external conditions are kept the same; but to secure the greatest divergence, in a given time, there must be both Diversity of Selection and complete Separation. In the case of Separation without Diversity of Selection there is room for difference of opinion; for the examples that some would claim as proving that there is often divergence without Diversity of Selection and without difference in external conditions may be attributed by others to unconscious Selection. It is granted by everyone that no skill in selecting the animals that possess the desired qualities will have any effect in establishing a new breed, unless the selected animals are prevented from breeding with others that are deficient in the desired qualities. We further find that while Separation is an absolutely essential condition for this divergence, Diversity of Selection is not so essential. This is illustrated in the case of the slightly different types that are presented by the wild cattle found in the different parks of England,* a phenomenon which can hardly be attributed to any diversity in the environment.

In artificial breeding universal experience teaches that Variation and Selection, without Separation, do not produce divergence of races. The separate breeding of different classes of variation is a necessary condition for the accumulation of divergent variation; and wherever the separate breeding of different classes of variation is secured, there divergence of character is the result. In other words, Segregate Breeding is necessary to divergent evolution in gamogenetic animals.† Moreover, we have every reason to believe that the same law holds good throughout the whole organic world. The generating together of similars, with the exclusion or separation of dissimilars, is the central necessity in all evolution by descent, whether monotypic or polytypic; and *whatever causes the separate generation of different classes of variation will be the cause of divergent evolution*. That is, wherever this condition is added to the permanent laws of organic life, there divergence will follow. As we have already seen, Natural Selection or the Survival of the Fittest necessarily separates between the survivors and the non-survivors, between the best fitted and the least fitted, and is, therefore, the cause of monotypic transformation; but it cannot be the cause of separation between the different families of those that survive, and, therefore, cannot be the cause of divergence of character between these families. But we find that divergence of character often arises between the branches of one stock, and in many cases this divergence increases till well-marked varieties are established. If, therefore, the general principle we have just stated is true, there must be certain causes producing the

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* See Darwin's 'Variation under Domestication,' chapter xv. 2nd page.

† In a subsequent paper I shall show how it is that Separate Breeding, long continued, inevitably ends in Segregate Breeding. In this chapter I confine my attention more especially to Separate Breeding when combined with Diversity of Selection in the different sections, for it is evident that this will produce Segregate Breeding.

Independent Generation of these forms; and, if we can discover these causes and trace them to general principles, they will, in connection with the laws of Variation and Selection, explain divergent evolution, that is the transformation of one form into many forms, of one species into many species. As community of evolution arises where there is community of breeding between those that through superior fitness have opportunity to propagate, so I believe it will be found that divergent evolution arises where there is separate breeding of the different classes of the successful. In other words, Exclusive Breeding of other than average forms causes Monotypic Evolution, and Segregate Breeding causes Divergent or Polytypic Evolution.

The facts of geographical distribution seem to me to justify the following statements:—

(1) A species exposed to different conditions in the different parts of the area over which it is distributed is not represented by divergent forms when free interbreeding exists between the inhabitants of the different districts. In other words, Diversity of Natural Selection without Separation does not produce divergent evolution.

(2) We find many cases in which areas, corresponding in the character of the environment, but separated from each other by important barriers, are the homes of divergent forms of the same or allied species.

(3) In cases where the separation has been long continued, and the external conditions are the most diverse in points that involve diversity of adaptation, there we find the most decided divergences in the organic forms. That is, where Separation and Divergent Selection have long acted, the results are found to be the greatest. The 1st and 3rd of these propositions will probably be disputed by few if by any. The proof of the 2nd is found wherever a set of closely allied organisms is so distributed over a territory that each species and variety occupies its own narrow district, within which it is shut by barriers that restrain its distribution, while each species of the environing types is distributed over the whole territory. The distribution of terrestrial mollusks on the Sandwich Islands presents a great body of facts of this kind.

SELECTION OF EVERY KIND INSUFFICIENT TO ACCOUNT FOR DIVERGENT EVOLUTION.

Though I have no reason to doubt the importance of Sexual Selection in promoting the transformation of many species, I think I can show that unless combined with some separative or segregative influence, that prevents free intercrossing, it can avail nothing in producing a diversity of races from one stock. In the nature of its action Sexual Selection is simply exclusive. It is the exclusive breeding of those better fitted to the sexual instincts of the species, resulting from the failure to breed of the less fitted. It therefore indicates a method of separation between the better fitted and the less fitted; but it gives no explanation of separation between those that are equally successful in propagating.

I maintain that in a great number of animal species there are sexual and social instincts that prevent the free crossing of clearly marked races; but as these segregative instincts are rarely the cause of failure to propagate, and since when they are the cause of failure the failure is as likely to fall on one kind as on another, I conclude that the Segregate Breeding resulting from these instincts cannot be classed as either Sexual or Social Selection. Reflexive Selection in all its forms is, like Natural Selection, the result of success and failure in vital processes through which the successful propagate without crossing with the unsuccessful; but it in no way secures the breeding in separate groups of those that are successful in propagating. The exclusion of certain competitors from breeding is a very different process from the separation of the successful competitors into different groups that are prevented from intercrossing, and whose competition even is often limited to the members of the same group. Sexual Selection, like other forms of Reflexive Selection, can extend only as far as members of the same species act on each other. If the individuals of two groups have through difference in their tastes ceased to compete with each other in seeking mates, they are already subject to different and divergent forms of Sexual Selection; and is there any reason to attribute this difference in their tastes to the fact that, when there was but one group and the tastes of all were conformed to a single standard, some of the competitors failed of propagating, through being crowded aside by those more successful? *If the* *failure of the unsuccessful cannot be the cause of separation between the different kinds of the successful, then Selection, whether Natural, or Reflexive, or of any other kind, cannot be the cause of Divergent Evolution, except as co-operating with some cause of Independent Generation.*

The failure of Sexual Selection, without Separation or Segregation, to account for divergent evolution, will perhaps be made clearer to some minds by considering some of the particular conditions under which it occurs. Suppose, for instance, that in some species of humming-bird there occurs a slight variation in the form or colour of the tail-feathers of the male that adds to the beauty of the individuals possessing the new character and rendering them more attractive to the females. We can see that they might have an advantage over their rivals in leaving progeny, and that the variety might in that way gradually gain the ascendency, and the beauty of the markings become more and more completely defined; but under such conditions what could prevent the whole species from being gradually transformed? Unless there was some separative or segregative principle that prevented the new variety from crossing with the others, the species would remain but one, though changed in some of its characters. We should have transformation without divergence.

The same must be true of Institutional Selection. It may be the cause of transformation; but it cannot be the cause of divergent evolution, unless there are added to it other causes that produce divergence in the character of the forms selected, and the separate breeding of the different groups of forms thus selected. A single illustration will set in a clear light the limitation in the influence of Institutional as well as all other Selection. In primitive communities the deaf are but little cared for, and owing to the great disadvantages of their position their opportunities for gaining subsistence, and therefore for rearing families, are greatly diminished: this is Natural Selection. Again, those who are at so great a disadvantage in communicating with their companions will be also at a disadvantage in finding consorts: this we may call Social Selection. Again, a community might either by law or by strict custom prevent the marriage of the deaf: this would be Institutional Selection. Any one of these forms of selection might be pressed so far as to be the means of increasing the average power of hearing in the community in succeeding generations; but it could never be the cause of two divergent races, one with good powers of hearing and the other with an increasing liability to deafness. To secure such divergence it is necessary that segregative influences should be introduced, such as have been most amply furnished by the modern system of education for the deaf. Under these influences those endowed with hearing and those without hearing have been separated into two communities, the members of each having but little opportunity for acquaintance beyond the limits of that community; each community having separate schools, separate newspapers, and to some extent a separate language. As the result of this segregation marriages between the two classes have been greatly diminished; and little by little two races are arising, the hearing race and the deaf race.*

REASONS OF A GENERAL CHARACTER FOR CONSIDERING SELECTION WITHOUT INDEPENDENT GENERATION AN UNSATISFACTORY EXPLANATION OF DIVERGENT EVOLUTION.

1. The divergence is often confined to characters which seem to have no possible relations of adaptation either to the environment or to other members of the species, and, therefore, to be independent of both Natural and Reflexive Selection.

2. Divergence relating to adaptive characters successfully propagated involves different kinds rather than different degrees of adaptation and advantage; and, as Adaptational Selection depends on the difference of degrees of advantage, it cannot account for the divergence of forms possessing equal degrees of advantage.

3. In the very nature of its action, we see that Adaptational Selection unaccompanied by Independent Generation must produce essentially monotypic transformation.

4. In artificial breeding, Independent Generation is found to be an essential condition for the production of divergent races; and there is no reason to doubt that the same law holds good in the divergence of natural forms.

5. The general fact that species possessing high powers and large opportunities for migration occupy large areas, while those

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* See paper by Alexander Graham Bell, read before the National Academy of Sciences, November 13, 1883, upon the "Formation of a Deaf Variety of the Human Race;" also a review of the same in 'The Popular Science Monthly,' vol. xxvii. p. 15, entitled "Can Man be Modified by Selection?"

possessing low powers and small opportunities for migration divide the same area, or an area no larger, between many representative species, shows that independent generation is an important element in their divergence.

CHAPTER II.

CUMULATIVE DIVERGENCE THROUGH CUMULATIVE SEGREGATION.

Local separation in dissimilar environments is the only cause of Segregation that has been clearly pointed out by Darwin. I shall, however, endeavour to show that there are other causes producing Segregation, and that, without any Change of Environment or change in the Environment, they may produce all the phenomena of Divergent Evolution. Any cause that, out of two or more kinds of successful variations, brings together one kind in such a way as to facilitate their breeding together, or to hinder their breeding with those of other kinds, is according to my definition a cause of Segregate Breeding; and the experience of breeders shows that wherever such causes operate divergent evolution is the result, and that the divergence accumulates when the process is continued through many generations. From their experiments we learn that any form of Segregate Breeding persistently continued will result in divergent evolution. As any form of natural selection in which other than typical forms have the advantage will result in Monotypic Evolution, so any form of segregate generation will produce Polytypic Evolution. I call this the law of *Cumulative Divergence through Cumulative Segregation.* It is a generalization established by the widest experience of mankind in the cultivation of plants and the breeding of animals; and any assumption that is not in accord with it may be wisely called in question.

I, therefore, judge that the advantage or disadvantage of their divergence, to individuals diverging from the typical form of a species, cannot be the factor that determines whether the divergence shall be accumulated.

A divergent member of any intergenerating group cannot long perpetuate its kind, if the divergence is any disadvantage; for the superior propagation of the more successful kinds will soon overpower the influence of the less successful; and the result will be Monotypic Evolution. The case is, however, very different with variations that are wholly or partially separated from each other and from the type by their divergent adaptation to different kinds of resources, or by any other cause. The perpetuation of such variations depends not upon any advantage they possess above the type from which they diverge, but upon ability to appropriate from the environment sufficient simply to maintain existence, and the result is Polytypic Evolution. In other words, of the freely crossing forms of any species it is only those that are most successful that are perpetuated; while *of forms that are neither competing nor crossing, every kind is perpetuated that is not fatally deficient in its adaptations.* It follows that a form that under present conditions maintains only a precarious existence may, if kept from crossing, maintain its characteristics unimpaired for many generations, and at last, through changes in the environment, enter upon a period of great prosperity. Such would be the case with a form depending upon resources at first scarce, and afterwards very abundant.

Again, the individuals of a species that are brought together in their attempts to appropriate some new kind of resource, and are thus led to breed with each other, and not with the rest of the species, become a new Intergenerating Group in which a new and divergent form of natural selection is established, depending on divergent adaptations in the organism, without any change in the environment. The gradual process of gaining full adaptation to the new resources may extend over many generations, and during this long period the divergent form may be at a great disadvantage as compared with the typical form; but after this long process of divergence is completed, and full command of the new resource is gained, the new race may enter upon a period of great prosperity. In such a case, the period of most rapidly accumulating divergence is a period when the incipient race is suffering the heaviest disadvantage. The transformation from a wild to a domestic state affords a complete parallel to this process. In the initial and earlier stages, the divergent branch that is being domesticated is in constant danger of extermination; and it is only when a good degree of adaptation to the new conditions has been gained that it can be said to be as prosperous as the wild stock from which it was derived. Darwin has not explained how disadvantageous sexual instincts can be formed; but, assuming that there are such instincts, he has shown that they would modify the species in a way that is disadvantageous. He believes the progenitors of man were deprived of their hairy coat by Sexual Selection that was, in its earlier stages, disadvantageous.

It is therefore evident that the simple fact of divergence in any case is not a sufficient ground for assuming that the divergent form has an advantage over the type from which it diverges. We may, however, be sure that there is some cause or combination of causes that facilitates the intergenerating of those similarly endowed, and hinders their crossing with other kinds; and if we can discover the cause of this Segregate Generation, we shall have an explanation of one part of the process by which the forms thus endowed are becoming a distinct race.

SEPARATION AND SEGREGATION WITH THE PRINCIPLE OF INTENSION.

It will contribute to clearness in our discussion if we can gain definite conceptions of the conditions that are necessarily involved in Separate and Segregate Breeding.

Separate Generation, which for convenience I call Separation, implies :—

1st. The indiscriminate separation of the members of a species into different sections that are prevented from freely crossing with each other.

2nd. The aggregation of the members of one section; that is, their being brought into conditions of time and place that allow of their freely crossing.

3rd. The integration of the members of each section into one intergenerating group, through the operation of functional adaptations by which the members of each section freely cross with each other. This analysis of the process shows that it may depend upon a great variety of causes, working together in a very complex way. We shall hereafter find that the causes of separation may operate in such a way that no aggregation or propagation takes place amongst the members that are separated from the old stock; but in such cases there is no Separate Generation, and therefore no Separation in the sense in which I use the word.

Segregate Generation also consists of separation, aggregation, and integration; but it differs from Separate Generation in that in the latter the separation is indiscriminate, while in the former there is a more or less pronounced bringing together of those that are similarly endowed, with separation of those that are dissimilar. Segregate Generation is therefore the separation of dissimilars, with the aggregation and integration of similars. As we have already seen, Segregate Breeding may be produced by Separate Breeding accompanied by Diversity of Natural Selection in the different sections. It is also evident that any other cause that develops in one or more of the separate sections of the species characters that are not found in the other sections will produce Segregate Breeding. Such cases are Diversity of Selection of other forms than Natural Selection, Diversity in the inherited effects of Use and Disuse (unless physiologists have been mistaken in supposing that there are any such effects), and Diversity in the inherited characters derived from the Direct Effects of the Environment (unless, again, Weismann is right and the general belief wrong). Segregate Breeding may, moreover, be produced directly by the very way in which the separation of the different sections is secured. One of the best examples of this kind of Segregation is seen in what I call Industrial Segregation, where the members of a species are distributed according to their endowments, those of similar endowments being brought together. In such cases, Segregation is introduced as soon as the Separation, without depending on the subsequent action of the environment, or on diverse forms of Use, or of Selection; though there can be no doubt that, in the great majority of cases, Diversity of Use and Diversity of Selection of some kind will in time come in to intensify the result.

There is another invariable sequence which it is necessary we should keep in mind, if we would understand the relation in which these two principles stand to each other. I refer to the certainty that all prolonged Separate Breeding will be transformed into Segregate Breeding. In other words, indiscriminate separation, in which there is no apparent difference in the different groups, is in time found to be a separation in which there is a decided difference in the different groups. Whenever a sufficient number of the same species to ensure propagation are brought together in an isolated position, Separate Generation is the result; and, if this Separate Generation is long-continued, we have reason to believe, it always passes into Segregate Generation with divergent evolution. The fundamental cause for this seems to lie in the fact that no two portions of a species possess exactly the same average character, and that the initial differences are for ever reacting on the environment and on each other in such a way as to ensure increasing divergence in each successive generation, as long as the individuals of the two groups are kept from intergenerating. In my paper on ***Diversity of Evolution under one Set of External Conditions***, I spoke of this principle of divergence as "Separation with Variation;" but in order to distinguish the antecedent condition, which is Separation, from the result, which is something more than Variation, I now call the certainty that some form of divergent transformation will arise when intergeneration is prevented the principle of ***Intension***; and Segregation produced by independent transformation I call Intensive Segregation.

As Separate and Segregate Generation are so closely related, I have, in order to avoid a multiplication of terms, classified the two principles together under the general term Segregation. In my discussion of the causes of Segregation I shall, however, endeavour to determine concerning each class of causes whether they are primarily Separative or Segregative.

A full discussion of the causes of Segregation would require that under each combination of causes to which we give a distinctive name we should show:—

1. How the Independent Generation is produced.
2. How the difference of character in the different sections is produced.
3. How the aggregation in place bringing together the members of each section is produced.
4. How the correspondence in times and seasons necessary for intergeneration is secured within each section.
5. How the correspondence of community and of Sexual and Social instincts necessary for intergeneration is secured within each section.
6. How the correspondence in structure, in dimensions, and in the mutual potentiality of the sexual elements necessary for intergeneration is secured within each section.

It will, however, be observed that, with the exception of the two first, these questions relate to the necessary conditions that must always exist in the case of every intergenerating group; and as it is evident that intergeneration in some degree must be the normal condition in every sexual, that is in every gamogenetic, species, we may here assume that all the conditions necessary to intergeneration exist, except so far as they have been disturbed by causes producing Segeneration. In tracing the causes of Segregation it will therefore be sufficient if in each class of cases we give the cause of Segeneration, showing why the same cause does not prevent all intergeneration, and explain the difference of character in the different sections produced by the Segeneration. In full accord with the implications of the theory of evolution, we proceed on the assumption that intergeneration was the original condition of every species, and that the intergeneration of those that are brought together under favourable circumstances may be taken for granted, unless there is some special cause that prevents. All that is necessary to produce Separation is the failure of any one of the many conditions on which free-crossing depends, in such a way, and to such a degree, that the species falls into two or more sections between which crossing is interrupted, without its being interrupted within the bounds of each section. And all that is necessary to produce Segregation is that to Separation should be added some cause that secures difference of character in the different sections. And as Separation long continued inevitably ends in Segregation through the development of difference of character in the different sections, we need not in our classification set them wholly apart, though for the sake of clearly recognizing the difference it will be well to note in each class of causes whether the primary effect is Separation or Segregation.

CUMULATIVE SEGREGATION AND THE CLASSIFICATION OF ITS DIFFERENT FORMS.

The fundamental law to which I would call attention may be expressed in the following formula:—Cumulative Segregation produces accumulated divergence; and accumulated divergence produces permanent Segregation; and the Segregate subdivision of those permanently Segregated produces the divisions and subdivisions of organic phyla. If, then, we can discover the causes of Segregation, we shall understand the causes of a wide range of phenomena; for this is the fundamental principle in the formation of varieties, species, genera, families, orders, and all greater divergences that have been produced in the descendants of common ancestry.

In treating of the causes of Segregation, I have found it convenient to make two distinct classifications. In the one the fundamental distinction is between segregation produced by the purpose of man, which I call

RATIONAL SEGREGATION, in its two forms:
ARTIFICIAL SEGREGATION,
INSTITUTIONAL SEGREGATION,

and that produced by nature outside of man, which I call

RESPONSIVE SEGREGATION;

while any of these forms of Segregation may be intensified by Independent transformation through the principles of Diversity of Selection, Diversity of Use, or Diversity of Direct Effects of the Environment; and the combined action of Segregation with these and other principles of transformation I call

INTENSIVE SEGREGATION.

In the other classification, the fundamental distinction is between segregation arising from the relations in which the organism stands to the environment, which I call

Environal Segregation,

and segregation arising from the relations in which the members of the same species stand to each other, which I call

Reflexive Segregation;

while any form of segregation belonging to either of these classes may be enhanced by one or more of the forms of Intension, and thus present what I call

Intensive Segregation.

THE EFFECTS OF SEGREGATION.

The effects of Segregation can be studied to advantage in the vast experience that has been accumulated in the domestication of plants and animals.

Artificial Segregation is caused by the relations in which the organism stands to the rational environment, that is to the purposes of man. In other words, Artificial Segregation is the rational form of Environal Segregation. Though the bearing of Segregation on the evolution of species in a state of nature has been for the most part overlooked, its effects have been quite familiar to the breeder of domestic races.

As a convenient method of illustration, let us consider the different results that will be gained according as we subject the same ten pairs of wild rock-pigeons to one or the other of the following methods of treatment.

In the first experiment let the treatment be as follows:—Let ten aviaries be prepared; and in each aviary put one male with the female that most nearly resembles it. When the young of each aviary arrive at maturity, let them be inspected, and if any individual resembles the inmates of one of the other aviaries more than the inmates of the aviary in which it was produced, let it be placed with those it most closely resembles. If any unusual variation arises, let it be placed in a new aviary, and let the one of the other sex that most closely resembles it in that respect be placed with it. When the crowding in any aviary becomes injurious to the health of the birds let the numbers be indiscriminately reduced. Let this process be continued many generations, the inmates in all the aviaries being fed on the same food, and in every respect treated alike, and what will be the result?

No experienced breeder will hesitate in assuring us that under such treatment a multitude of varieties will be formed, many of which will be very widely divergent from the original wild stock. In other words, *Cumulative Segregation will produce accumulated divergence, though there is no Selection in the sense in which Natural Selection is Selection.*

Again, let us take the same ten pairs, and putting them into one large aviary, let them breed freely together without any Segregative influence coming in to affect the result; and who does not know that the type would remain essentially one though a considerable range of individual variation might arise. That is, *without Segregation no divergence of type will arise.*

THE NATURAL LAW OF CUMULATIVE SEGREGATION.

I shall now show that there is in nature a law of Cumulative Segregation. There are large classes of activities in the organism and in the environment that conspire to produce Segregate Breeding; and to produce it in such a way that, in a vast multitude of cases, it becomes a permanent fact, which no cause that we are acquainted with can ever obliterate. Moreover, when one form of Segregation has become fully established, we find that the different branches are liable to be again subjected to segregative influences, by which each branch is subdivided, and in time differentiated into divergent forms that are not liable to intercross in a state of nature.

Now, as we have just pointed out, we know, from the fundamental laws of the organic world, that Cumulative Segregation of this kind must produce Cumulative Divergence of Types.

The Segregation that results from the natural causes enumerated in this paper is cumulative in two respects. In the first place, every new form of segregation that now appears depends on, and is superimposed upon, forms of Segregation that have been previously induced; for when Negative Segregation arises, and the varieties of a species become less and less fertile with each other, the complete infertility that has existed between them and some other species does not disappear, nor does the Positive Segregation (that is, the prevention of the consorting of the species characterized by this mutual incapacity) cease. The means by which the males and females of one species find each other are not abrogated when the species falls into segregated varieties. In the second place, whenever Segregation is directly produced by some quality of the organism, variations that possess the endowment in a superior degree will have a larger share in producing the segregated forms of the next generation, and accordingly the Segregative endowment of the next generation will be greater than that of the present generation; and so with each successive generation the segregation will become increasingly complete.

The principle of Cumulative Segregation, first in its independent action, and still further when combined with the different principles by which the divergence of the segregated branches is intensified, gives a formal explanation of the ever-expanding diversities of the organic world. It shows how varieties arise and pass into species, how species pass into genera, genera into families, families into orders, and orders into classes and the higher divisions, as far as evolution by descent extends. It brings to light the dependence of this whole process on the influences that produce segregation; and shows how these influences, added to Variation, Heredity, and the other acknowledged powers residing in organisms, must produce the phenemena of divergent evolution.

COMPETITIVE DISRUPTION.

Before entering upon the discussion of the direct causes of Cumulative Segregation, let us briefly consider a law resulting from the competition of kindred with each other, which brings to light the fact that such competition is one of the most important factors in preparing the way for, and in giving intensity to, the activities that lead to Segregation and divergent evolution. It is manifest that competition for identical resources and Geographical Segregation are conditions which cannot exist at the same time between the same members of any species; but it is also manifest that, when there are no natural barriers separating the different districts of an area part of which is occupied by a species, pressure for food through a great increase in the population will tend to distribute the species over the whole area; and, if the available resources in the different districts are considerably diverse, the overflow of population from the crowded district will be subjected to a necessary change of habits; and thus, through competition, there will be the disruption of old relations to the environment, and the bringing in of conditions that give the highest efficiency and the fullest opportunity to all the activities that produce Segregation. In the case of animals, no condition can tend more strongly to produce migration than scarcity of food in the old habitat; and in the case of both plants and animals, a great increase in the numbers that are exposed to the winds, currents, and other transporting influences of the environment increases the probability that individuals will be carried to new districts where circumstances will allow of their multiplying, and where they will, at the same time, be prevented from crossing with the original stock. In many cases the segregation thus brought about will be in districts where the environment is the same, and in other cases the pressure for food or other resources will lead portions of the species to take up new habits in the effort to appropriate resources not previously used; and through these new habits they will often be segregated from those maintaining the original habits. I shall hereafter show that in both these cases there is a tendency to divergent evolution.

I at one time thought of describing this principle as a form of Segregation, calling it *dominational segregation*; but fuller reflection convinces me that the domination of the strong over the weak is not a form of Segregation, but rather a cause that prepares the way for Segregation, by forcing portions of the community out of their inherited relations to the environment.

CHAPTER III.

DESCRIPTION AND CLASSIFICATION OF THE CAUSES OF CUMULATIVE SEGREGATION.*

A. ENVIRONAL SEGREGATION.

Environal Segregation is Segregation arising from the relations in which the organism stands to the environment.

It includes four classes, which I call Industrial, Chronal, Spatial, and Artificial Segregation.†

(*a*) INDUSTRIAL SEGREGATION

is Segregation arising from the activities by which the organism protects itself against adverse influences in the environment, or by which it finds and appropriates special resources in the environment.

The different forms of Industrial Segregation are Sustentational, Protectional, and Nidificational Segregation.

For the production of Industrial Segregation it is necessary that there should be, in the same environment, a diversity of fully and of approximately available resources more or less separated from each other, and in the organism some diversity of adaptation to these resources, accompanied by powers of search and of discrimination, by which it is able to find the resources for which it is best fitted and to adhere to the same when found.

The relation in which these causes stand to each other and through which they produce segregation may be described as separation according to endowment produced by endeavour according to endowment.

It is evident that if initial variation presents in any case a diversity of adaptations to surrounding resources that cannot be followed without separating those differently endowed, we shall have, in the very nature of such variation, a cause of segregation and of divergent evolution. Some slight variation in the digestive powers of a few individuals makes it possible for them to live exclusively on some abundant form of food, which the species has heretofore only occasionally tasted. In the pressure for food that arises in a crowded community these take up their permanent abode where the new form of food is most accessible, and thus separate themselves from the original form of the species. These similarly endowed forms will therefore breed together, and the offspring will, according to the law of Divergence through Segregation, be still better adapted to the new form of food. And this increasing adaptation, with increasing divergence, might continue for many generations, though every individual should come to maturity and propagate; that is, though there were no enhancing of the effect through Diversity of Selection, or indeed through any other cause producing Intensive Segregation. And when different forms of Intension do arise, they may be entirely independent of change in the environment, the only change being in the forms or functions of the organism.

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* In the following chapters numerals are attached to what I consider separate causes of segregation independent of human purpose.

† Francis Galton has suggested another class, which might appropriately be called Fertilizational Segregation.

In choosing a name for this form of Segregation I first thought of calling it Physiological or Functional Segregation. But such a name is, on closer examination, found to imply both too much and too little; for on the one hand there is probably no form of segregation that is not in some way or in some degree due to physiological or functional causes, and on the other hand this special form of segregation is as dependent on psychological causes which guide the organism in finding and in adhering to the situation for which it is best fitted, as it is on the initial divergence of the more strictly physiological adaptations by which it is able to appropriate and assimilate the peculiar form of resource. In the case of freely moving animals, the psychological guidance is an essential factor in the success of the individual; while in the case of plants and low types of animal life, the suitable situation is reached by a wide distribution of a vast number of seeds, spores, or germs, and the same situation is maintained by a loss of migrational power as soon as the germs begin to develop. In these lower organisms it is evident that the success of the individual must depend on its physiological rather than on its psychological adaptations; and if an initial divergence of adaptations results in a slight difference in the kinds that succeed in germinating in contrasted situations, the difference is directly due to a Diversity in the forms of Natural Selection affecting the seed, and the Separation is what I hereafter describe as Local Separation passing into Local Segregation. We therefore see that what I here call Industrial Segregation depends on psychological powers acting in aid of divergent physiological adaptations to the environment, or in aid of adaptations that are put to different uses.

Observation shows that there is a multitude of cases in which Endeavour according to Endowment brings together those similarly endowed and causes them to breed together; and when the species is thus divided into two or more groups somewhat differently endowed, there will certainly be an increased divergence in the offspring of the parents thus Segregated; and so on in each successive generation, as long as the individuals find their places according to their endowments, and thus propagate with those similarly endowed, there will be accumulated divergence in the next generation. Indeed it is evident that Endeavour according to Endowment may produce under one environment what Natural Selection produces when aided by local separation in different environments. As it produces the separate breeding of a divergent form without involving the destruction of contrasted forms, it is often the direct cause of divergent transformations; while Natural Selection, which results in the separate breeding of the fitted through the failure of the unfitted, can never be the cause of divergence, unless there are concurrent causes that produce both divergent forms of Natural Selection, and the separate breeding of the different kinds of variations thus selected.

Suetudinal Intension.—Another law is usually believed to be connected with Endeavour which, if it exists, must conspire to enhance its tendency to produce divergent evolution. I refer to the influence which the habitual endeavour of the parents has on the inherited powers of the offspring. We may call it the law of Endowment of Offspring according to the Exercise or Endeavour of Parents, or more briefly Suetudinal Intension. The inherited effects of use and disuse have been fully recognized by Darwin, Spencer, Cope, Murphy, and others, and need not here be discussed. The one point to which I wish to call attention is, that in order that diversity of use should produce divergent evolution, it is necessary that free crossing should be prevented between the different sections of the species in which the diversity of use is found. Now this condition of separate breeding is often secured by Industrial Segregation. In other words, the law of Endeavour according to Endowment, often secures Separation according to endowment; and this gives an opportunity for the inheritable effects of diversity of endeavour to be accumulated in successive generations; and in this way both laws conspire to produce divergent evolution.

In the relation of these two factors we have a striking example of the peculiar interdependence of vital phenomena. Diversity of endowment is the cause of diversity of endeavour and of Segregate Breeding, and diversity of endeavour with Segregate Breeding is the cause of increased diversity of endowment. It is very similar to the relation between power and exercise in the individual. Without power there can be no exercise, and without exercise there can be no continuance or growth of power.

We, therefore, see that the effects of Industrial Segregation are specially liable to be enhanced by that form of Intensive Segregation which I have suggested should be called Suetudinal Intension.

Simple and familiar as the principles of Industrial Segregation and Suetudinal Intension may seem, their consistent application to the theory of evolution will throw new light on a wide range of problems. This law of divergent evolution through Industrial Segregation rests on facts that are so fully acknowledged by all parties, that it seems to be a superfluous work to gather evidence on the subject. It may, however, be profitable to consider briefly whether the cases are frequent in which different habits of feeding, of defence, or of nest-building become the cause of separate breeding by which the same habits are maintained in one line of descent without serious interruption for many generations. It is important to remember, (1) that the separate breeding will arise with equal certainty whether the diversity in the habits has been initiated by original diversity in the instincts and adaptations of the different variations, or by the crowding of population inducing special efforts to find new resources, and leading to diversity of endeavour; and (2) that in either case the result is what is here called Industrial Segregation. In the first case the process is directly Segregative, while in the second case it is primarily Separative, but (according to the principle discussed in the second section of last chapter) inevitably passes into Segregate Breeding. Suetudinal Intension, or Divergent

Evolution through Diversity of Use, will operate as surely in the one case as in the other.

1. *Sustentational Segregation* arises from the use of different methods of obtaining sustentation by members of the same species.

There can be no doubt that of the innumerable cases where phytophagic varieties (as they are sometimes called) of insects exist, a considerable proportion would be found on investigation to be permanent varieties producing offspring that are better adapted to the use of the special form of food consumed by the parents than are the offspring of other varieties; and it is evident that if the peculiar habits of each variety had no tendency to produce segregative breeding this result would not be reached; for each variety would be promiscuously mingled with every other, and, though the tendency to variation might be greatly increased, the regular production of any one variety of young would be prevented.

A large mass of facts could be easily gathered illustrative of Sustentational Segregation: but as the principle will probably be denied by no one, we shall pass on without further expansion of this part of the subject.

2. *Protectional Segregation* is Segregation from the use of different methods of protection against adverse influences in the environment.

When a new enemy enters the field occupied by any species different methods of escape or defence are often open to the members of the one species; and the use of these different methods must sometimes result in the segregation of the members according to the methods adopted. Some may hide in thickets or holes, while others preserve themselves by flight. Supposing the species to be an edible butterfly occupying the open fields, and the new enemy to be an insectivorous bird also keeping to the open country, certain members might escape by taking to the wood-lands, while others might remain in their old haunt, gaining through Protectional Selection more and more likeness to some inedible species.

3. *Nidificational Segregation.*—Let us now consider the effects of divergent habits in regard to nest-building. It is well known to American ornithologists that the Cliff Swallow of the eastern portions of the United States has for the most part ceased to build nests in the cliffs that were the original haunts of the

species, and has availed itself of the protection from the weather offered by the eaves of civilized houses; and that with this change in nest-building has come a change in some of its other habits. Now there is reason to believe that if the number of houses had been limited to a hundredth part of those now existing, and if that limited number had been very slowly supplied, this gradual change in some of the elements of the environment would have resulted in divergent forms of adaptation to the environment in two sections of the same species. One section would have retained the old habit of building in the cliffs, with all the old adaptations to the circumstances that depend on that habit; while another section of the species would have availed itself of the new opportunities for shelter under the eaves of houses, and would have changed their inherited adaptations to meet the new habits of nest-building and of feeding. It is also evident that the prevention of free interbreeding between the different sections caused by the diversity of habits would have been an essential factor in the divergence of character in the sections.

It simply remains to consider whether the industrial habit that separates an individual from the mass of the species will necessarily leave it alone, without any chance of finding a consort that may join in producing a new intergenerant. The answer is that there is no such necessity. Though it may sometimes happen that an individual may be separated from all companions by its industrial habit, it is usually found that those that at one time and one place adopt the habit are usually sufficient to keep up the new strain, if they succeed in securing the needed sustenance.

(*b*) CHRONAL SEGREGATION

is Segregation arising from the relations in which the organism stands to times and seasons.

I distinguish two forms—Cyclical and Seasonal Segregation.

4. *Cyclical Segregation* is Segregation arising from the fact that the life cycles of the different sections of the species do not mature in the same years.

A fine illustration of this form of Segregation is found in the case of *Cicada septemdecim*, whose metropolis is in Virginia, Maryland, and Delaware, though many out-lying broods are found in other regions east of the Mississippi River. The typical form has a life-cycle of seventeen years, but there is a special race (*Cicada tredecim*, Riley) that is separated from the typical form, both locally and chronally. As the life-cycle of this race is thirteen instead of seventeen years, even if occupying the same districts and breeding at exactly the same season, interbreeding could occur between the two forms only once in 221 years, or once in 13 generations of the longer lived race, and once in 17 generations of the shorter lived race. During the year 1885 the two races appeared simultaneously. The opportunity for testing whether they would freely interbreed if brought together has, therefore, passed not to return till the year 2106; but the distribution of the two races in different districts seems to indicate that Local Segregation has had an important influence in the development of the race. It is manifest, however, that if during a period of local separation, or if during the period of 221 years of Cyclical separation after the thirteen-year race was first formed, this race should become modified in the season of its appearing, there would after that be no mingling of race, though brought together in the same districts. This would be Seasonal Segregation, which we shall consider in the next section; but what is of special interest here, as an example of complete Cyclical Segregation, is the fact that at Fall River, Massachusetts, there is a brood of the *septemdecim* form, due a year later than the universal time of appearing.*

In any species where the breeding of each successive generation is separated by an exact measure of time which is very rigidly regulated by the constitution of the species, Cyclical Segregation will follow, if, through some extraordinary combination of circumstances, members sufficient to propagate the species are either hastened or delayed in their development, and thus thrown out of synchronal compatibility with the rest of the species. If, after being retarded or hastened in development so that part of a cycle is lost or gained, the old constitutional time measure reasserts itself, the Segregation is complete.

So far as this one point relating to the time of maturing is concerned the constitutional difference is segregative, while in every other respect it will be simply separative, except as separation passes into Segregation. The Fall-River brood of *Cicada*

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* See statement by Prof. C. V. Riley, in 'Science,' vol. vi. p. 4. For particulars concerning the distribution and habits of this species see a paper by Prof. Riley, read before the Biological Society of Washington, May 30, 1885, extracts from which are given in 'Science,' vol. v. p. 518.

septemdecim being entirely separated from all other broods of the same race by being belated a year, may be modified by forms of Natural Selection that never arise in these other broods. And this may be the case even if a brood observing the ordinary time is always associated with it in locality.

5. *Seasonal Segregation* is produced whenever the season for reproduction in any section of the species is such that it cannot interbreed with other sections of the species. It needs no argument to show that if, in a species of plant that regularly flowers in the Spring, there arises a variety that regularly flowers in the autumn, it will be prevented from interbreeding with the typical form. The question of chief interest is, under what circumstances are varieties of this kind likely to arise? Is a casual sport of this kind likely to transmit to subsequent generations a permanently changed constitution? If not, how is the new constitution acquired? One obvious answer is that it may arise under some special influence of the environment upon members of the species that are geographically or locally segregated from the rest of the species.

But may not the variation in the season of flowering be the cause of segregation that will directly tend to produce greater variation in that respect in the next generation, and so on till the divergence in the constitutional adaptation to season is carried to the greatest extreme that is compatible with the environment? I believe that it not only may, but must have that effect; but we should remember that the average form which flowers at the height of the season will so vastly predominate over the extreme forms that the latter will be but stragglers in comparison.

In regard to the one point of the season of readiness for propagation, this principle is segregative; but in other respects it is simply separative, unless through the principle of correlated variation other characters are directly connected with the constitution that determines the season. It will be observed that Seasonal Segregation is produced by a parallel and simultaneous change in the constitution of members in one place sufficient to propagate the species; while Cyclical Segregation is produced by a simultaneous acceleration or retardation in the development of members in one place sufficient to propagate the species without disturbing the regular action of the constitution under ordinary circumstances.

(c) SPATIAL SEGREGATION

is Segregation arising from the relations in which the organism stands to space.

I distinguish two forms, viz. Geographical and Local Segregation.

Geographical Segregation is Segregation that arises from the distribution of the species in districts separated by geographical barriers that prevent free interbreeding. Decided differences of climate in neighbouring districts and regions may be classed as geographical barriers.

Local Segregation is Segregation that arises when a species with small powers of migration and small opportunities for transportation has been, in time, very widely distributed over an area that is not subdivided by geographical barriers. The Segregation in this case is due to the disproportion between the size of the area occupied and the powers of communication existing between the members of the species occupying the different parts of the area. Though it is often difficult to say whether a given case of Segregation should be classed as Geographical or Local, still the distinction will be found useful; for the results will differ according as the Segregation is chiefly due to barriers or to wide diffusion of the species. In Geographical Segregation the result is usually the development of well-defined varieties or species on opposite sides of the barriers; but in Local Segregation it often happens that the forms found in any given locality are connected with those in surrounding localities by individuals presenting every shade of intermediate character; and in general terms it may be said that the forms most widely separated in space are most widely divergent in character. It is of course apparent that when the divergence has reached a certain point the differentiated forms may occupy the same districts without interbreeding, for they will be kept apart by some, if not all, of the different forms of Industrial, Chronal, Conjunctional, and Impregnational Segregation.

Three different forms of Spatial Segregation may be distinguished according to the causes by which they are produced, viz.:—

6. *Migrational Segregation*, caused by powers of locomotion in the organism.

7. *Transportational Segregation*, caused by activities in the environment that distribute the organism in different districts, (prominent among these are currents of atmosphere and of

water, and the action of migratory species upon those that can simply cling).

8. *Geological Segregation*, caused by geological changes dividing the territory occupied by a species into two or more sections. For example, geological subsidence may divide the continuous area occupied by a species into several islands, separated by channels which the creatures in question cannot pass.

Migration differs from transportation simply in that the former is the direct result of activities in the organism, and the latter of activities in the environment; and though the distribution of every species depends on the combined action of both classes of activities, it is usually easy to determine to which class the carrying power belongs. The qualities of the thistle-down enable it to float in the air, but it is the wind that carries it afar.

Some degree of Local Segregation exists whenever the members of a species produced in a given area are more likely to interbreed with each other than with those produced in surrounding areas, or whenever extraordinary dispersal plants a colony beyond the range of ordinary dispersal. In other words, when those produced in a given district are more nearly related with each other than with those produced in surrounding districts, there local segregation has existed.

There is one important respect in which Spatial Segregation differs from all other forms of Environal Segregation, namely, in its ordinary operation it does not depend directly upon diversity in the qualities and powers of the organism. The dispersion of the members of a species would not be prevented if each was exactly like every other; though, of course, if there were no power of variation, separate breeding would have no influence in producing divergence of character. It follows that every species is, or is more or less liable to be, affected by Spatial Segregation; and it often happens that other forms of Segregation arise through the previous operation of this form; but as Spatial Segregation prevents organisms from crossing only when separated in space, it must always be reinforced by other forms of segregation before well-defined species are produced that are capable of occupying the same district without interbreeding. The vast majority of the divergent forms arising through Local Segregation are reintegrated with the surrounding forms, new divergences constantly coming in to take the place of the old;

but if, during its brief period of local divergence, Industrial or Chronal Segregation is introduced, the variety becomes more and more differentiated, and, as one after another the different forms of Reflexive Segregation arise, it passes into a well-defined species. There is, however, reason to believe that the order of events is often the reverse, Reflexive forms of Segregation being the cause of the first divergences.

As Spatial Segregation does not depend upon diversity in the qualities and powers of the organism, so also it does not usually result in distributing the organism in different localities according to their differences of endowment. The causes that produce it are primarily separative, not segregative.

Migration is produced by the natural powers of the organism, acting under the guidance of instincts that usually lead a group of individuals, capable of propagating the species, to migrate together; while the organisms that are most dependent on activities in the environment for their distribution, are usually distributed in the form of seeds or germs, any one of which is capable of developing into a complete community.

The causes of Separation between the different sections, and of Integration between the members of one section, are therefore sufficiently clear; but what are the causes of difference of character in the different sections, especially when they are exposed to the same environment? These causes all come under what I call Intensive Segregation, which, for the sake of saving repetition, will be fully discussed in a separate paper.

(*d*) 9. FERTILIZATIONAL SEGREGATION.

Since writing this chapter on Environal Segregation, I have seen Francis Galton's short article on "The Origin of Varieties" published in 'Nature,' vol. xxxiv. p. 395, in which he refers to a cause of segregation that had not occurred to me. He says:—"If insects visited promiscuously the flowers of a variety and those of the parent stock, then—supposing the organs of reproduction and the period of flowering to be alike in both, and that hybrids between them could be produced by artificial cross-fertilization—we should expect to find hybrids in abundance whenever members of the variety and those of the original stock occupied the same or closely contiguous districts. It is hard to account for our not doing so, except on the supposition that insects feel repugnance to visiting the plants interchangeably."

Following the form of nomenclature adopted in this paper, I venture to call this principle Fertilizational Segregation.

It is evident that Segregation of this form depends on divergence of character already clearly established, and therefore on some other form of Segregation that has preceded. It is also segregative rather than separative, in that it perpetuates a segregation previously produced, which might otherwise be obliterated by the distribution of the different forms in the same district. The form of Segregation that precedes Fertilizational Segregation, producing the conditions on which it depends, must, from the nature of the case, be Local Segregation. Chronal and Impregnational Segregation, when imperfectly established, might be fortified by Fertilizational Segregation; but, in the case of plants, these are all dependent on previous Local Segregation.

(*e*) ARTIFICIAL SEGREGATION.

Artificial Segregation is Segregation arising from the relations in which the organism stands to the rational environment. As the operation of this cause is familiar, and as it was considered in the last chapter when discussing the effects of segregation, we pass on, simply calling attention to the fact that it is a form of Environal Segregation.

THE IMPORTANCE OF ENVIRONAL SEGREGATION.

We must not assume that the various forms of Environal Segregation are of small influence in the formation of species because Sexual or Impregnational Incompatibility is a more essential feature, without which all other distinctions are liable to be swept away. The importance of the forms of segregation discussed in this chapter lies in the fact that they often open the way for the entrance of the more fundamental forms of segregation, even if they are not essential conditions for the development of the same. Though myriads of divergent forms produced by Local and Industrial Segregations are swept away in the struggle for existence, and myriads are absorbed in the vast tides of crossing and intercrossing currents of life, the power of any species to produce more and more highly adapted variations, and to segregate them in groups that become specially adapted to special ends, or that grow into specific forms of beauty and internal harmony, is largely dependent on these factors.

CHAPTER IV.

DESCRIPTION AND CLASSIFICATION OF THE CAUSES OF CUMULATIVE SEGREGATION *(continued)*.

B. REFLEXIVE SEGREGATION.

Reflexive Segregation is Segregation arising from the relations in which the members of one species stand to each other.

It includes three classes, which I call Conjunctional, Impregnational, and Institutional Segregation.

It is important to observe that Intergeneration requires compatibility in all the circle of relations in which the organism stands; but, in order to ensure Segeneration between any two or more sections of a species, it is sufficient that incompatibility should exist at but one point. If either sexual or social instincts do not accord, if structural or dimensional characters are not correlated, if the sexual elements are not mutually potential, or if fixed institutions hold groups apart, Intergeneration is prevented, and Segeneration is the result, either as Segregation, or as Separation that is gradually transformed into Segregation.

(*a*) CONJUNCTIONAL SEGREGATION.

Conjunctional Segregation is Segregation arising from the instincts by which organisms seek each other and hold together in more or less compact communities, or from the powers of growth and segmentation in connection with self-fertilization, through which similar results are gained.

I distinguish four forms—Social, Sexual, Germinal, and Floral Segregation.

10. *Social Segregation* is produced by the discriminative action of social instincts.

The law of social instinct is preference for that which is familiar in one's companions; and, as in most cases the greatest familiarity is gained with those that are near of kin, it tends to produce breeding within the clan, which is a form of Segregate Breeding. If the clan never grows beyond the powers of individual recognition, or if the numbers never become so great as to impede each other in gaining sustenance, there will be but little occasion for segregation; but multiplication will lead to segmentation. Wherever the members of a species, ranging freely over a given area, divide up into separate herds, flocks, or swarms, of which the members produced in any one clan breed with each other more than with others, there we have Social Segregation.

It should always be kept in mind that Social Segregation arises at a very early stage, holding apart groups not at all or but very slightly differentiated; while in the case of many animals, the eager sexual instincts of the males constantly tend to break up these minor groups. Though the barriers raised by social insincts are often broken over, their influence is not wholly overcome; and in many intstances the Social Segregation becomes more and more pronounced, till in time decided Sexual Segregation comes in to secure and strengthen the divergence.

11. *Sexual Segregation* is produced by the discriminative action of sexual instincts.

There can be no doubt that sexual instincts often differ in such a way as to produce segregation. But how shall we account for these differences? In the case of Social Segregation there is no difficulty, for it seems to be, like migration, due to a constant instinct, always tending to segregation. We also see that an endowment which prevents the destruction of the species through the complete isolation of individuals, and which co-operates with migrational instincts in securing dispersal without extinction, may be perfected by the accumulating effects of its own action. And is there any greater difficulty in accounting for the law that regulates sexual instincts? If it can be shown that Vigour and Variation, the conditions on which adaptation depends, are in their turn dependent on some degree of crossing, there will be no difficulty in attributing the development of an instinct that secures the crossing to the superior success of the individuals that possess it in even a small degree. On the other hand, whenever there arises a variety that can maintain itself by crosses within the same variety, any variation of instinct that tends to segregation will be preserved by the segregation. It needs no experiments to prove that, if the members of a species are impelled to consort only with the members of other species, they will either fail to leave offspring, or their offspring will fail to inherit the characteristics of the species. The same is true concerning the continuance of a variety that is not otherwise segregated. The power of variation on the one hand, and the power of divergent accumulation of variations on the other hand, are prime necessities for creatures that are wresting a living from a vast and complex environment; and the former is secured by the advantage over rivals possessed by the variations that favour crossing, and the latter by the better escape from the swamping effect, and sometimes from the competition of certain rivals, secured by the more segregative variations. We must therefore believe that, whenever in the history of an organism there arise segregative variations which are able to secure sufficient sustentation and propagation to continue the species, the segregative quality of the forms thus endowed will be preserved and accumulated through the self-accumulating effect of the segregative endowments.

It is probable that in many of the higher vertebrates sexual instincts tend to bring together those of somewhat divergent character, but the difference preferred is within very narrow limits; and beyond those limits, it may be said that the general law for sexual attraction is, that it varies inversely as the difference in the characters of the races represented, if not inversely as some power of such difference. The action of such a law is necessarily segregative, whenever the divergence has, through other causes, passed beyond the limit of higher attraction. Before Sexual Segregation can arise, there must arise distinctive characteristics by means of which the members of any section may discriminate between those of their own and other sections. If there are no constant characteristics, there can be no constant aversion between members of different groups, no constant preference of those of one's own group. From this it follows, that before Sexual Segregation can arise, some form of Segregation that is not dependent on accumulated divergence of character must have produced the divergence on which the Sexual Segregation depends. Such forms are Local, Social, and some kinds of Industrial Segregation. When varieties have arisen through these causes, it often happens that Sexual Segregation comes in and perpetuates the Segregation which the initial causes can no longer sustain. As long as the groups are held apart by divergent sexual instincts, it is evident that divergent forms of Sexual Selection are almost sure to arise, leading to a further accumulation of the divergence initiated by the previous causes.

If there is any persistent cause by which local and social groups are broken up and promiscuously intermingled before recognizable characters are gained, the entrance of Sexual Segregation will be prevented. I therefore conclude that the chief influence of this latter factor is found in its prolonging and fortifying the separate breeding of varieties that have arisen under Local, Social, or Industrial Segregation, and in thus continuing the necessary condition for the development of increasingly divergent forms of Intensive Segregation, under which the organism passes by the laws of its own vital activity when dealing with a complex environment in groups that never cross.

12. *Germinal Segregation* is caused by the propagation of the species by means of seeds or germs any one of which, when developed, forms a community so related that the members breed with each other more frequently than with the members of other communities. If the constitution of any species is such that the ovules produced from one seed are more likely to be reached and fertilized by pollen produced from the same seed than by pollen produced from any other one seed, then Germinal Segregation is the result.

In order to secure this kind of Segregation it is not necessary that the flowers fertilized by pollen from the same plant should be more fertile, or the seeds capable of producing more vigorous plants than the flowers fertilized by pollen from another plant. All that is required is that of the seeds produced a larger number shall be fertilized by the pollen of the same plant than by the pollen of any other one plant.

This form of Segregation is closely related to Local Segregation on one side, and to Social Segregation on the other. It, however, differs from the former in that it does not depend on Migration or Transportation, and from the latter in that it does not depend on social instincts.

13. *Floral Segregation* is Segregation arising from the closest form of self-fertilization, namely the fertilization of the ovules of a flower by pollen from the same flower.

Many plants that in their native haunts are frequently crossed by the visits of insects depend entirely on self-fertilization when transported to other countries where no insect is found to perform the same service for them. The common pea (*Pisum sativum*) is an example of a species that habitually fertilizes itself in England, though Darwin found that it was very rarely visited by insects that were capable of carrying the pollen.* Darwin also mentions *Ophrys apifera* as an orchid which "has almost certainly been propagated in a state of nature for thousands of generations without having been once intercrossed." *

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* See 'Cross- and Self-Fertilization in the Vegetable Kingdom,' p. 161.

General Observations on Germinal and Floral Segregation.

A fact of great importance in its bearing on the origin of varieties should be here noted. Any variation, arising as a so-called sport, in any group of plants where either of these principles is acting strongly will be restrained from crossing, and will be preserved except in so far as reversion takes place. Now there is always a possibility that some of the segregating branches of descent will not revert, and that, through the special character which they possess in common, they will some time secure the services of some insect that will give them the benefit of cross-fertilization with each other without crossing with other varieties. The power of attaining new adaptations may be favoured by self-fertilization occasionally interrupted by interbreeding with individuals of another stock; for the latter is favourable as introducing vigour and variation, and the former as giving opportunity for the accumulation of variations.

(*b*) IMPREGNATIONAL SEGREGATION.

Impregnational Segregation is due to the different relations in which the members of a species stand to each other in regard to the possibility of their producing fertile offspring when they consort together.

In order that Impregnational Segregation should be established and perpetuated it is necessary, 1st, that variation should arise from which it results that those of one kind are capable of producing vigorous and fertile offspring in greater numbers when breeding with each other than when breeding with other kinds; 2nd, that mutually compatible forms should be so brought together as to ensure propagation through a series of generations. In order to secure this second condition, it is necessary that, in the case of plants, there should be some degree of Local, Germinal, or Floral Segregation, and, in the case of animals that pair, either pronounced Local Segregation, or partial Local Segregation supplemented by Social or Sexual Segregation. The first of these factors I call Negative Segregation, as contrasted with all other forms of Segregation, which I group together as Positive Segregation.

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* See 'Cross- and Self Fertilization in the Vegetable Kingdom,' p. 439.

Of each form of Segregation which we have up to this point considered, the segregating cause has been one that distributes individuals of the same species in groups between which free intergeneration is checked; while the propagation of the different groups depends simply on the original capacity for intergenerating common to all the members of the species. The intercrossing has been limited not by the capacity, but by the opportunity and inclination of the members. Coming now to cases in which the lack of capacity is the cause that checks the production of mongrels, we find a dependence of a very different kind; for to ensure the propagation of the different groups it is not enough that the general opportunity for the members to meet and consort remains unimpaired. There must be some additional segregating influence bringing the members together in groups corresponding to their segregate capacity, or they will fail of being propagated.

A partial exception must be made in the case of Potential and Prepotential Segregation, the latter being due to the prepotency of the pollen of a species or variety on the stigma of the same species or variety, and the former to the complete impotence of the foreign pollen. When allied species of plants are promiscuously distributed over the same districts, and flowering at the same time, prepotency of this kind is one of the most direct and efficient causes of Segregate Breeding. The same must be true of varieties similarly distributed whenever this character begins to affect them. In the case, however, of diœcious plants and of plants whose ovules are incapable of being impregnated by pollen from the same plant, no single plant can propagate the species. If, therefore, the individuals so varying as to be prepotent with each other are very few and are evenly distributed amongst a vast number of the original form, they will fail of being segregated through failing to receive any of the prepotent pollen. It is thus apparent that when the mutually prepotent form is represented by comparatively few individuals, their propagation without crossing will depend on their being self-fertile and subject to Germinal or Floral Segregation, or on their being brought together by some other form of Positive Segregation.

When a considerable number of species of plants are commingled and are flowering at the same time, their separate propagation is preserved, in no small degree, by the Prepotential Segregation of those that are most nearly allied, and by the complete Potential Segregation of those that belong to different families, orders, and classes. The same principle must come in to prevent the crossing of different species, genera, families, and orders of animals whose fertilizing elements are distributed in the water. We must, therefore, consider it a form of Positive as well as Negative Segregation; for the free distribution of the fertilizing element, with the superior affinity of the two sexual elements when produced by those that are mutually prepotential, secures the interbreeding of those that are mutually prepotential.

Impregnational Segregation generally exists between the different species of the same genus, almost always between species of different genera, and always between species of different families, orders, classes, and all groups of higher grade. And in all these cases it is associated with other forms of segregation, and whenever it has once become complete, it has never been known to give way. Though complete mutual sterility never gives place to complete mutual fertility, in every case where the descendants of the same stock have developed into different classes or orders, and in most cases where they have developed into different families or genera, the reverse process has taken place, and complete mutual fertility has given place to complete mutual sterility.

Under Impregnational Segregation I distinguish five principles: namely, Segregate Size, Segregate Structure, Potential and Prepotential Segregation, Segregate Fecundity, and Segregate Vigour.

14. *Segregate Size* is caused by incompatibility in size or dimensions.

As familiar illustrations of this form of Segregation, I may mention the following:—The largest and smallest varieties of the ass may run in the same pasture without any chance of crossing. I have also kept Japanese bantam fowls in the same yard with other breeds without any crossing. In many other species individuals of extreme divergence in size are incapable of interbreeding.

15. *Segregate Structure* is caused by the lack of correlation in the proportionate size of different organs and by other incompatibilities of structure.

Darwin suggests that the impossibility of a cross between certain species may be due to a lack of correspondence in length of the pollen-tubes and pistils. Such a lack of harmony would perhaps account for difference of fertility in reciprocal crosses.

Segregate Structure does not usually arise till other forms of Segregation have become so well established that difference of structure does not make any essential difference in the amount of intergeneration. It is not, however, impossible that species that would otherwise be fertile *inter se* are thus held apart. In Broca's work on 'Human Hybridity'* there is a passage quoted from Prof. Serres, showing that it is very possible that this form of incompatibility may exist between certain races of man.

16. *Potential Segregation and Prepotential Segregation.*—These are caused by more or less free distribution of the fertilizing element together with the greater rapidity and power with which the sexual elements of the same species, race, or individual combine, as contrasted with the rapidity and power with which the elements of different species, races, or individuals combine. Potential Segregation is caused by the mutual impotence of the contrasted forms, as is always the case between different orders and classes; and Prepotential Segregation is caused by the superior influence of the fertilizing element from the same species, race, or individual, as contrasted with that from any other species, race, or individual, when both are applied to the same female at the same time, or sometimes when the prepotent element is applied many hours after the other.

For the operation of this principle the fertilizing element from different males must be brought to the same female.

When pollen from a contrasted genus, order, or class has no more effect than inorganic dust, it seems appropriate that we should call the result Potential Segregation rather than Prepotential Segregation, which implies that the foreign as well as the home pollen is capable of producing impregnation. Prepotential Segregation may be considered the initial form of Potential Segregation, the former passing through innumerable grades of intensity into the latter. We may, therefore, consider the principles as fundamentally one, though it will be convenient to retain both names.

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* English translation published by the Anthropological Society of London, p. 28.

The importance of this principle in producing and preserving the diversities of the vegetable kingdom can hardly be overstated. If pollen of every kind were equally potent on every stigma, what would the result be? What distinctions would remain? And if Potential Segregation is necessary for the preservation of distinctions, is it not equally necessary for their production? Amongst water-animals that do not pair, the same principle of Segregation is probably of equal importance. Concerning this form of Segregation many questions of great interest suggest themselves, answers to which are not found in any investigations with which I am acquainted. Some of these questions are as follows:—

(1) Are there many cases of Prepotential as well as of Potential Segregation between different forms of water-animals?

(2) Is Prepotential Segregation always accompanied by Segregate Fecundity and Segregate Vigour?

(3) If not always associated, which of the three principles first appears? And what are their relations to each other?

(4) When allied organisms are separated by complete Environal Segregation, are they less liable to be separated by these three principles?

Darwin has in several places referred to the influence of prepotency in pollen, and in two places I have found reference to the form of prepotency that produces segregation; but I find no intimation that he regarded this or any other form of segregation as a cause of divergent evolution, or as a necessary condition for the operation of causes producing divergent evolution. The effect of prepotency in pollen from another plant in preventing self-fertilization is considered in the tenth chapter of his work on 'Cross- and Self-Fertilization in the Vegetable Kingdom,' pp. 391–400. Some very remarkable observations concerning the prepotency of pollen from another variety from that in which the stigma grows are recorded in the same chapter; but no reference is there made to the effect that must be produced when the pollen of each variety is prepotent on the stigma of the same variety. In the sixteenth chapter of 'Variation under Domestication,' it is suggested that prepotency of this kind might be a cause of different varieties of double hollyhock reproducing themselves truly when growing in one bed; though there was another cause to which the freedom from crossing in this case had been attributed. Again, in chapter viii. of the fifth edition * of 'The Origin of Species,' in the section on "The Origin and Causes of Sterility," Darwin, while maintaining that the mutual sterility of species is not due to Natural Selection, refers to prepotency of the kind we are now considering as a quality which, occurring in ever so slight a degree, would prevent deterioration of character, and which would therefore be an advantage to a species in the process of formation, and accordingly subject to accumulation through Natural Selection. In order to construct a possible theory for the introduction of sterility between allied species by means of Natural Selection, he finds it necessary simply to add the supposition that sterility is directly caused by this prepotency. He, however, for several reasons concludes that there is no such dependence of mutual sterility on the process of Natural Selection. Concerning the prepotency he makes no reservation, and I accordingly judge that he continued to regard it as strengthened and developed through the action of Natural Selection.

It is concerning this last point that I wish to give reasons for a different opinion. I believe that qualities simply producing Segregation can never be accumulated by Natural Selection; for:—

(1) When separate generation comes in between two sections of a species they cease to be one aggregate, subject to modification through the elimination of certain parts. Both will be subject to similar forms of natural selection only so long as the circumstances of both and the variations of both are nearly the same, but they will no longer be the members of one body between which the selecting process is carried out. On the contrary, if they occupy the same district each group will stand in the relation of environment to the other, modifying it, and being modified by it, without mutually sharing in the same modification.

(2) Though one may exterminate the other, the change that comes to the successful group through the contest is not due to its superiority over the other, but to the superiority of some of its own members over others.

(3) When any Segregate form begins to arise we cannot attribute its success to the advantage of segeneration, for the inter-

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* Since my comments on this passage were written, I have discovered that Darwin has omitted it from the sixth edition.

generating forms are at the same time equally successful; wherefore it is not the success, but the separateness of the success, that is due to the segeneration.

(4) The continuance of the descendants of a group in a special form will depend on its Segregation; but this is a very different thing from the special success of its descendants. The preservation of a *special kind* of adaptation is never due to natural selection, which is the superior success of the higher *degrees* of adaptation of every kind.

(5) The power of migration, or any other power directly related to the environment, may be accumulated by natural selection, and afterward lead to Segregation; but, according to my method of judging, the continuous advantage of Segregation over Integration can never be shown, for both are equally essential in the economy of nature; and though one process may at one time predominate over the other, the comparative advantage of Segregation, if there be such advantage, cannot be the cause of the preservation of forms endowed with segregative qualities, for they will certainly be preserved as long as they are able to win a bare existence, which is often a lower grade of success than the one from which they are passing.

(6) According to my view, instead of the accumulation of the Segregative prepotency depending on natural selection, the accumulation of divergent forms of natural selection depends on some form of Segregation.

But if the accumulation of Prepotential Segregation is not due to Natural Selection, how shall we explain it? It is, I think, due to the fact that those forms that have the most of this character are, through its action, caused to breed together. We have already seen, when considering Seasonal and Sexual Segregation, that, if Segregation is directly produced by the instincts or physiological constitution of the organism, there is a tendency toward an increasing manifestation of the character in successive generations. Those that have but a slight degree of Segregate prepotency eventually coalesce, forming one race, while those possessing the same character in a higher degree remain more distinct, and their descendants become still more segregate and still more permanently divergent. As long as the segregate forms are able to maintain vigour and secure fair sustentation, the process continues and the separation becomes more pronounced. Of this form of the Law of Cumulative Segregation we may say that, as the descendants of the best fitted necessarily generate with each other and produce those still better fitted, so the descendants of those possessing the most segregative endowments necessarily generate with each other and produce those that are still more segregate.

It may at first appear that a slight degree of prepotence will prevent crossing as effectually as a higher degree; but further reflection will show that the efficiency of the prevention will vary in direct proportion with the length of time over which the prepotent pollen is able to show its prepotence, and this will allow of innumerable grades. If, in the case of certain individuals, the prepotency is measured by about twenty minutes, while with other individuals it enables the pollen of the same variety to prevail, though reaching the stigma an hour after the pollen of another variety has been applied, the difference in the degree of Segregation will be sufficient to make the persistence of the latter much more probable than that of the former. This form of Segregation is evidently one of the important causes preventing the free crossing of different species of plants. It probably has but little influence on terrestrial animals; but how far it is the cause of Segregation among aquatic animals is a question of no small interest, concerning which I have but small means for judging. I have, however, no hesitation in predicting that, unless we make the presence of this Segregative quality the occasion for insisting that the forms so affected belong to different species, we shall find that amongst plants the varieties of the same species are often more or less separated from each other in this way. I do not know of any experiments that have been directed toward the determining of this point; but on the general principle that physiological evolution is not usually abrupt, and that race distinctions are the initial forms under which specific differences present themselves, I can have no doubt that feeble prepotence precedes that which is more pronounced, and that part of this divergence in many cases takes place, while the divergent branches may be properly classed as varieties. Another reason for believing that Prepotential Segregation will be found on further investigation to exist in some cases between varieties, is the constancy with which, in the case of species, this character is associated with Segregate Fecundity and Segregate Vigour, which we know are sometimes characteristics of varieties in their relation to each other. The importance of these latter principles when occurring in connection with different forms of partial Segregation will now be considered.

17, 18. *Segregate Fecundity and Segregate Vigour.*—By Segregate Fecundity I mean neither Segregation produced by Fecundity nor Fecundity produced by Segregation, but the relation in which species or varieties stand to each other when the intergeneration of members of the same species or variety results in higher fertility than the crossing of different species or varieties. In like manner Segregate Vigour is the relation in which species or varieties stand to each other when the intergeneration of members of the same species or variety produces offspring more vigorous than those produced by crossing with other species or varieties. Integrate Fecundity and Integrate Vigour are the terms by which I indicate the relation to each other of forms in which the highest fertility and vigour are produced by crossing, and not by independent generation.

Before discussing these principles through which the influence of Segregation is greatly increased, it will be an advantage if we can gain some idea of the nature of Cumulative Fertility in its relations to a law of still wider import. I refer to the fourfold law of antagonistic increase and mutual limitation between (1) Integration, (2) Segregation, (3) Adaptation, (4) Multiplication—in other words between (1) General invigoration and power of variation through crossing, (2) The opening of new opportunities and independent possibilities, (3) Special adaptation to present circumstances, (4) Powers of multiplied individualization. Darwin has considered at length the 1st and the 3rd, though I do not remember that he has anywhere pointed out that their development is due to a kind of self-augmentation. I believe this is so emphatically the case that the former might well be called the law of Self-Cumulative Vigour, and the latter the law of Self-Cumulative Adaptation. Corresponding to these two laws, I find the additional laws of Self-Cumulative Segregation and Self-Cumulative Fertility. Darwin's theory, that Diversity of Natural Selection is directly and necessarily dependent on exposure to different external conditions, tends to obscure, though not to deny, the fact that the breeding together of the better adapted, which causes the increase of adaptation, is due to the different degrees of endowment in the organism, rather than to diversity in the environment. It is also true of segregative endowment and of fertility that they are necessarily cumulative whenever they belong in different degrees to members of the same Intergenerant that are equally fitted. The cumulation of vigour, as that of adaptation, is, I think, rightly classed as a form of Selection; for in both cases it depends on the power of the more highly endowed to supplant the less endowed without allowing them full opportunity to propagate; but the increase of segregative endowments and of fertility is due to principles quite different from this, and differing from each other. The segregative endowments augment through the inherent tendency of the more highly endowed to breed more exclusively with those of the same form, and therefore in the long run to breed more exclusively with each other; while the fertility of the more fertile neither drives out the less fertile nor holds the two classes apart, but simply multiplies the offspring of the more fertile, making it sure that in each generation they will predominate.

But all these forms of augmentation correspond in that they secure the breeding together of those possessing higher degrees of the special endowment, and so increase the average endowment, either of the whole number of the offspring, or of the segregated portion. Vigour increases through the breeding together of the more vigorous, resulting from their overcoming and crowding out the less vigorous without allowing them full opportunity to propagate. Adaptation increases through the breeding together of the better adapted, resulting from their supplanting their rivals without allowing them full opportunity to propagate. Segregative endowments increase through the breeding together of the more highly endowed, resulting from the fact that as long as Segregation is incomplete more than half of each generation of pure descent are necessarily the offspring of parents whose segregative endowments were above the average. Fertility increases through the breeding together of the more fertile, resulting from the fact that more than half of each generation are the offspring of parents of more than average fertility. As the breeding together of the more vigorous and the better adapted, caused by their superior success, tends to increase and intensify the vigour and adaptation of successive generations, so the breeding together of those more highly endowed with Segregative powers, caused by the Segregation, tends to strengthen and intensify the Segregative powers in successive generations; and so the breeding together of the more fertile, caused by the larger proportion of offspring produced by the more fertile, tends to increase the fertility of successive generations. Among those that would be equally productive if equally nourished, the ratio of propagation varies directly as the degree of sustentation above a certain minimum (and perhaps below a certain maximum), and therefore directly as the degree of adaptation that secures this sustentation. This *propagation according to degrees of adaptation to the environment is what I understand by natural selection.* But among those that are equally adapted to the environment the ratio of propagation varies directly as the ratio of fertility. This *propagation according to degrees of fertility is what I call the Law of Cumulative Fertility.* It is not due to different degrees of success, or to any advantage which the individuals of one form have over those of other forms; but simply to the higher ratio of multiplication in the more fertile forms securing the intergeneration of the more fertile. *In connection with natural selection it ensures, in the descendants, the predominance of the better adapted of the more fertile, and the more fertile of the better adapted.*

At the close of the previous chapter I called attention to the fact that innumerable Local Segregations and other imperfect forms of Segeneration are being constantly broken down, partly by the increase of numbers and partly by the superior fertility and vigour of offspring produced by crossing. It seems to be a fundamental law that vigour and variation in the offspring depend on some degree of diversity of constitution in the parents, and diversity of constitution that is not entirely fluctuating depends on some degree of Positive Segregation; therefore vigour and variation depend on the breaking-down of incipient Segregations, and on the interfusion of the slightly divergent forms that had been partially segregated. But in the history of every race that is winning success by its vigour and variation there is liable to come a time when some variety, inheriting sufficient vigour to sustain itself, even if limited to the benefits of crossing with the individuals of the same variety, becomes partially Segregated. As we have already seen, Segregation, in so far as it depends on the qualities of the organism, tends ever to become more and more intense; but, in the very nature of things, not only will the Segregation be for many generations only partial, but partial Segregation, though it may greatly delay the submerging of different groups in one common group, will never prevent that result being finally reached. Though the siphon that connects two tanks of water be ever so small, the water will in time find a common level in both tanks, unless there are additions or subtractions of water that prevent such a result. So, in the case under consideration, final fusion will take place, unless differentiation progresses more rapidly than the fusion, or some other influence comes in to counteract the levelling influence of occasional crosses. If, under such conditions, some branch of the partially Segregated variety becomes more fertile when generating with members of the same variety, and less fertile when generating with other varieties, a principle will be introduced tending to strengthen any form of partial Segregation that already exists between the varieties. This principle when co-operating with partial Segregation will produce pure masses of each variety, when, without the action of this principle, all distinctions would be absorbed by the crossing. We know that a transition from Integrate Fecundity to Segregate Fecundity usually takes place at a point in the history of evolution intermediate between the formation of an incipient variety and a strongly-marked species; and though the causes that produce this transition may be very difficult to trace, I believe the results that must follow can be pointed out with considerable clearness and certainty.

Darwin's investigations have shown that in many cases, if not in the majority, the relation of varieties to each other is that which I have called Integrate Fecundity and Integrate Vigour; that is, the highest fertility is attained when varieties are crossed, and the vigour of offspring thus produced is greater than when the intergeneration is within the limits of one variety. He, however, gives in 'Variation under Domestication,' chapter xvi., some special cases, in which "varieties of the same species behave, when crossed, like closely allied but distinct species"; and remarks that similar cases "may not be of very rare occurrence; for the subject has not been attended to." The same cases are also mentioned in all the editions of the 'Origin of Species.' *

The problems that arise in considering the different results produced by different degrees of Positive Segregation and Segregate Fecundity are of a nature suitable for mathematical treatment. Before, however, computing the effects of Segregate Fecundity when co-operating with Positive Segregation, it will be in place to show that it is of itself only a negative form of

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* See 1st edition, p. 238; 5th edition, p. 259; 6th edition, p. 258.

Segregation, having no power to ensure the propagation of the varieties thus characterized, though they are fully adapted to the environment. This is most easily brought to light by considering the effect of a high degree of this quality when Positive Segregation is entirely wanting, or when it is sufficient to give simply a chance of Segregate Breeding by bringing each individual near to its natural mate. For example, let us suppose, 1st, that a male and a female each of several allied but mutually sterile species are brought together on one small island, all other tendences to Positive Segregation being removed, while mutual sterility still remains; 2nd, that a male and female when once mated remain together for the breeding-season; and 3rd, that all find mates. Now, if we have 7 species, each represented by one individual of each sex, what is the probability that all the species will be propagated? And what the probability for the propagation of none, or of but one, or of but two, or of but three of the species? The answers, as I have computed them, are as follows:—The probability that none will be propagated is $\frac{1854}{5040}$; that 1 species will be is $\frac{1855}{5040}$; that 2 species $\frac{924}{5040}$; that 3 species $\frac{315}{5040}$; that 4 species $\frac{70}{5040}$; that 5 species $\frac{21}{5040}$; that 7 species $\frac{1}{5040}$. These numerators are found in the 7th line of a table of figures which I call the Permutational Triangle. If we have 10 species, the probability that in any one trial no species will match truly and be propagated is $\frac{1334961}{3628800}$; that 1 species will match truly and propagate is $\frac{1334960}{3628800}$; that 10 will is $\frac{1}{3628800}$. This means that if 3,628,800 trials are made, one of them will probably be a case in which each male pairs with the female of the same species, while 1,334,961 will be cases in which none are so matched, and 1,334,960 will be cases in which one pair is so matched. It therefore appears that more than $\frac{8}{11}$ of the probabilities are against the continuance of more than one of the ten species.

There will perhaps be some hesitation in receiving these figures before I have given the method by which the results have been reached; but the necessary length of this paper, even when restricted to the briefest discussion of general principles, induces me to reserve my computations for another occasion. It is not, however, necessary to have a complete solution of this problem, in order to reach the conclusion that the origin of separate races and species depends not only upon their adaptation to the environment and their mutual sterility when crossing with each other, but also upon their Positive Segregation. We can further see (when considering an extreme case, like either of the above-supposed cases) that Segregate Fecundity, without the aid of Positive Segregation, must lead to extinction. We have already seen that partial Segregation cannot by itself prevent the fusion of species. It therefore follows that in order to account for the continuance of divergent races we must suppose either that the Segregation is complete, or that the divergent evolution is strong enough to more than counterbalance the influence of the occasional crossing, or that the partial Segregation is aided by Segregate Fecundity or Segregate Vigour.

Between the members of species belonging to different orders we find not only complete Segregation, but complete sterility when attempts at crossing are made; but hope of gaining an explanation of how these characteristics have arisen is found, not in the study of those cases in which the process has been completed, but in the study of the relations to each other of species and varieties that are characterized by partial Segregation and mutual sterility, that is not complete. Here, again, mathematical analysis will help us in understanding the subject. Though I have not succeeded in constructing a complete mathematical representation of all the grades of intermingling that will take place, I have found a general formula that gives a close approximation to the proportion in which two species will breed pure as contrasted with the proportion of first crosses and their descendants that will be produced, in any case in which the degree of Segregation and the ratios of fertility for the pure and crossed breeds are known. As my object is simply to show under what conditions the pure races will continue without being swamped by crossing, it is not necessary that I should follow the action and reaction between the three-quarter-breeds. I wish, however, to call attention to the fact that when the number of the pure forms and of the half-breeds is constantly decreasing, without a general decrease in the sum of the descendants, it is evident that the three-quarter-breeds and their descendants are increasing; and when a three-quarter-breed on one side crosses with a three-quarter-breed on the other side, the offspring will usually be about intermediate between the two species; therefore, where the two species are equally numerous, if we find that the pure forms will disappear through fusion, we may expect that the three-quarter-breeds will also disappear through fusion.

In constructing my formula, it was found necessary to commence by placing in the 1st generation of the half-breeds a more or less arbitrary symbol; for the true symbol in each case is the final one reached in the nth generation when n is a very high number. The chief interest therefore centres in what can be accomplished through the use of this formula for the nth generation. It seems to me to furnish a method of reaching the final proportion of pure breeding that will be produced by any form of combination between Positive Segregation and Segregate Fecundity, and to give results that would require thousands of years of continuous experimenting to reach in any other way.

Method of using Table III. (see p. 255).

By supposing n to be an indefinitely high number, and by giving different values to M, m, and c, we shall have the the means of contrasting the number of the pure-breeds with that of the half-breeds, when the process has been long continued under different degrees of Positive Segregation and Segregate Fecundity.

In the first place let us take a case in which there is no Segregate Fecundity, that is $M=m$; and for convenience in computation let us make $M=1$, $m=1$. In every case where m is not larger than M the fraction $\frac{(1-2c)m}{M-Mc}$ is less than unity, and the sum of the geometrical progression of our formula will fall within the limits of a number that can be easily computed by the well-known formula $S=\frac{a}{1-q}$, in which a is the first number of the progression, which in this case is 1, and q is the fraction we are now considering. Supposing $c=\frac{1}{10}$, the fraction will be $\frac{(1-\frac{2}{10})1}{1-\frac{1}{10}}=\frac{8}{9}=q, \therefore S=\frac{a}{1-q}$ becomes $S=\frac{1}{1-\frac{8}{9}}=\frac{9}{9-8}=9$. This number 9 is therefore equal to the sum of this progression and can therefore be used as the value of the infinite progression in the formula for the nth generation when n is a very high number. Substituting these values we find that the nth generation of the half-breeds equals the nth generation of the pure forms, each being equal to $\frac{9}{10}$ of $A\ (M-Mc)^{n-1}$. $A(M-Mc)^{n-1}$ is a vanishing quantity, for $M-Mc$ is less than 1. Every form is therefore in time fused with other forms. But let us try higher

TABLE I.

Arithmetical Computation, showing the number of Half-breeds as contrasted with the Pure-breeds, when $\frac{9}{10}$ of each variety form unions among themselves and double with each generation, while the offspring of the $\frac{1}{10}$ that form mixed unions simply equal the number of the parents by which they are produced: in other words when $c=\frac{1}{10}$, $M=2$, $m=1$ (see Table II.).

Variety No. 1, Pure-breeds.				*Of what generation.*	*Half of the Half-breeds.*	*Three-quarter breeds on one side.*	*Variety No. 2, Pure-breeds.*
1,000	=	A	=	Initial number			1,000
1·8							
1,800	=	A (1·8)	=	1st generation.	100		1,800
1·8							
3,240	=	$A (1·8)^2$	=	2nd ,,	260	20	3,240
1·8							
5,832	=	$A (1·8)^3$	=	3rd ,,	532	72	5,832
$357·05=(1·8)^{10}$ computed by log.							
∴ 357,050	=	$A (1·8)^{10}$	=	10th ,,	35,688		357,050
$39,347·272=(1·8)^{18}$							
∴ 39,347,272	=	$A (1·8)^{18}$	=	18th ,,	3,934,725		39,347,272

EXPLANATION OF TABLE I.

The 2nd generation of the half-breeds is found by taking $\frac{9}{10}$ of the previous half-breeds, *i. e.* $100\times\frac{9}{10}=90$, and $\frac{1}{10}$ of the previous pure-breeds (the $\frac{1}{10}$ that form mixed unions), minus $\frac{1}{10}$ of the previous half-breeds (because $\frac{1}{10}$ of the half-breeds consort with an equal number of pure-breeds, and so produce not half-breeds but three-quarter-breeds), *i. e.* $180-10=170$. Adding these two sums together we have $90+170=260$=The 2nd generation of half-breeds.

As in this Table the computation commences without any half-breeds, the following generations of half-breeds are all a little less than $\frac{1}{10}$ as large as the corresponding generations of pure breeds. When, however, we come to the 18th generation the difference is less than one in a million, and we may consider the result as practically corresponding with the formula for the *n*th generation, given in Table III.

The Three-quarter-breeds are obtained by multiplying $\frac{1}{10}$ of the previous generation of half-breeds by 2, and adding to the result the sum of the previous generations of three-quarter-breeds. This of course gives a number too large; for some of the three-quarter-breeds will fail to breed with three-quarter-breeds. A closer expression of the proportion between pure-breeds and three-quarter-breeds is given in Tables VII. and VIII.

TABLE II.

Preliminary Formula for showing the Proportion of Half-breeds to Pure-breeds.

Let $R =$ the ratio of pure breeding, *i. e.* the Segregation.
Let $c =$ the ratio of cross-breeding.
Ex. When $\frac{9}{10}$ of the unions are within the limits of the species and $\frac{1}{10}$ of the unions are with an allied species $R = \frac{9}{10}$, $c = \frac{1}{10}$. R will always equal $1 - c$.
Let $M =$ the ratio of fertility in each generation for those that breed with their own kind.
Let $m =$ the ratio of fertility in each generation for the cross-unions and for the hybrids when breeding together.
Let $A =$ the initial number of individuals representing the pure species when the computation commences.

Number of individuals representing the Pure form.	*Number of individuals representing the Half-breeds.*
A = Initial number.	
$A(RM)$ = 1st generation.	1st generation $= Acm$.
$A(RM)^2$ = 2nd ,,	2nd ,, $= (AcmR + A(RM)c - Acmc) \times m$.*
$A(RM)^3$ = 3rd ,,	2nd ,, $= (AcmR - Acmc)m + Acm(RM)$.
$A(RM)^4$ = 4th ,,	2nd ,, $= Acm(R - c)m + Acm(RM)$.
Substituting $(1-c)$ for R in the 2nd gen., we have	Substituting in this $(1-c)$ for R, we have
$A(M - Mc)^2 =$ 2nd generation.	2nd generation $= Acm(1-2c)m + Acm(M - Mc)$.

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* The term $AcmR$ represents the number of half-breeds that form unions among themselves, the offspring being half-breeds; $A(RM)c$ represents the total number of pure-breeds of the 1st generation that form mixed unions; of these $Acmc$ form unions with an equal number of half-breeds, and their offspring being three-quarter-breeds must be rejected; the remainder, namely $A(RM)c - Acmc$, form unions with the other race, and their offspring are half-breeds of the 2nd generation.

TABLE III.

Developed Formula for Segregation and Segregate Fecundity, giving the proportion of Half-breeds to Pure-breeds.

Pure-breeds.	*Half-breeds.*
A = Initial number.	
$A(M-Mc)$ = 1st generation.	1st generation $= Amc$.
$A(M-Mc)^2$ = 2nd ,,	2nd ,, $= Amc(1-2c)m + Acm(M-Mc)$.
$A(M-Mc)^3$ = 3rd ,,	3rd ,, $= Amc((1-2c)m)^2 + Acm(M-Mc)(1-2c)m + Acm(M-Mc)^2$.
$A(M-Mc)^4$ = 4th ,,	4th ,, $= Amc((1-2c)m)^3 + Acm(M-Mc)((1-2c)m)^2 + Acm(M-Mc)^2(1-2c)m + Acm(M-Mc)^3$.
	4th ,, $= Amc(M-Mc)^3\left(\frac{((1-2c)m)^3}{(M-Mc)^3} + \frac{((1-2c)m)^2}{(M-Mc)^2} + \frac{(1-2c)m}{(M-Mc)} + \frac{(M-Mc)^3}{(M-Mc)^3}\right)$.
$A(M-Mc)^n$ = nth ,,	nth ,, $= Amc(M-Mc)^{n-1} \times \left(\left(\quad\right)^{n-1} + \left(\quad\right) + \left(\quad\right)^3 + \left(\quad\right)^2 + \left(\frac{(1-2c)m}{M-Mc}\right)^1 + 1\right)$.

1*st Rule.*—The Pure-breeds of any generation are found by multiplying the previous generation of pure-breeds by $M-Mc$, and the half-breeds of any generation are found by multiplying the previous generation of half-breeds by $(1-2c)m$ and adding the previous generation of pure-breeds multiplied by cm.

2*nd Rule.*—The nth generation of pure-breeds $= A(M-Mc)^n = A(M-Mc)^{n-1} \times (M-Mc)$; and the nth generation of half-breeds $= Amc(M-Mc)^{n-1}$ multiplied by the sum Σ of the series $1 + \frac{(1-2c)m}{M-Mc} + \ldots\ldots$, containing as many terms as that expressed by the number of the generation, *i. e.* containing n terms, of which the first is 1; $\therefore \frac{H}{P} = \frac{mc}{M-Mc}\Sigma\left(1 + \frac{(1-2c)m}{M-Mc} + \ldots\ldots\right)$; H being the number of Half-breeds, and P being the number of Pure-breeds.

3*rd Rule.*—To correct this formula, so that it shall indicate the proportions that will result when the relative vigour of pure and cross breeds is considered, we must substitute MV for M, and mv for m; V being the proportion of each generation of pure-breeds that grow to maturity and propagate, and v being the proportion of half-breeds that do the same.

degrees of Segregation. If we make $c=\frac{1}{100}$ or $\frac{1}{1000}$, we still find that Half-breeds= Pure-breeds, while the latter are constantly decreasing, which shows that imperfect Positive Segregation, without the aid of some quality like Segregate Fecundity, cannot prevent a species being finally fused with other species, as long as the whole number of each successive generation does not increase.

Let us now consider cases in which the Segregation is incomplete but Segregate Fecundity comes in to modify the result. Let $M=2$, $m=1$, $c=\frac{1}{10}$. Substituting these values in our formula, we shall find that the sum of the infinite progression is $\frac{9}{5}=\frac{18}{10}$. And $M-Mc=\frac{18}{10}$, which makes the half-breeds = the pure forms $\times cm$; and $cm=\frac{1}{10}$. Let $M=2$, $m=1$, $c=\frac{1}{100}$; then Half-breeds=Pure forms $\times\frac{1}{100}$. Let $M=2$, $m=1$, $c=\frac{1}{2}$; then the infinite progression$=1$, $M-Mc=1$, and the pure forms in each generation will equal A, and the half-breeds $A\times\frac{1}{2}$. Therefore Half-breeds= Pure-breeds $\times\frac{1}{2}$.

Let $M=3$, $m=2$, $c=\frac{1}{2}$; then the sum of the infinite progression$=1$, and the Half-breeds$=\frac{1}{2}\times 2\times A(M-Mc)^{n-1}$, and the Pure-breeds$=1\frac{1}{2}\times A(M-Mc)^{n-1}$; therefore Half-breeds= Pure-breeds $\times\frac{2}{3}$.

Let $M=3$, $m=2$, $c=\frac{1}{3}$; then Half-breeds=Pure-breeds $\times\frac{2}{4}$.
Let $M=3$, $m=2$, $c=\frac{1}{4}$; then Half-breeds=Pure-breeds $\times\frac{2}{5}$.
Let $M=3$, $m=2$, $c=\frac{1}{5}$; then Half-breeds=Pure-breeds $\times\frac{2}{6}$.
Let $M=3$, $m=2$, $c=\frac{1}{10}$; then Half-breeds=Pure-breeds $\times\frac{2}{11}$.
Let $M=3$, $m=2$, $c=\frac{1}{100}$; then Half-breeds = Pure-breeds $\times\frac{2}{101}$.

TABLE IV.

Simplified Formulas for the Proportions in which Half-breeds and Three-quarter-breeds stand to Pure-breeds when all are equally vigorous.

From Table III. we learn that

$$\frac{H}{P}=\frac{mc}{M-Mc}\times\left(1+\frac{(1-2c)m}{M-Mc}+\ \cdot\ \cdot\ \ \right).$$

Whem $(1-2c)m$ is less than $M-Mc$, the series within the brackets is a decreasing geometrical progression, and we may obtain the value of the whole series by the formula $S=\frac{a}{1-q}$. Applying this formula we have

$$\frac{H}{P}=\frac{mc}{M-Mc}\times\frac{1}{1-\frac{(1-2c)m}{M-Mc}}$$

$$=\frac{mc}{\mathrm{M}-\mathrm{M}c}\times\frac{\mathrm{M}-\mathrm{M}c}{\mathrm{M}-\mathrm{M}c-m+2mc}$$

$$=\frac{mc}{\mathrm{M}-m+(2m-\mathrm{M})c}. \quad \text{. . . . . (Formula 1)}$$

$$\therefore\ \mathrm{H}=\mathrm{P}\times\frac{mc}{\mathrm{M}-m+(2m-\mathrm{M})c}. \quad \text{. . . . . (2)}$$

If m'= the ratio of fertility for the Three-quarter-breeds, then according to the reasoning given in Tables VII. and VIII.,

$$\frac{\mathrm{T}}{\mathrm{H}}=\frac{2m'c}{\mathrm{M}-m'+(2m'-\mathrm{M})c}; \quad \text{. . . . . (3)}$$

and $$\frac{\mathrm{T}}{\mathrm{P}}=\frac{\mathrm{H}}{\mathrm{P}}\times\frac{\mathrm{T}}{\mathrm{H}}. \quad \text{. (4)}$$

The following solutions, as well as those given in Table V., are obtained by substituting values for M, m, and c in formula (2):—

When M=4, m=3, then if

$c=\frac{1}{2}$, Half-breeds = Pure-breeds $\times\frac{3}{4}$,
$c=\frac{1}{3}$, ,, = ,, $\times\frac{3}{5}$,
$c=\frac{1}{4}$, ,, = ,, $\times\frac{3}{6}$,
$c=\frac{1}{5}$, ,, = ,, $\times\frac{3}{7}$,
$c=\frac{1}{6}$, ,, = ,, $\times\frac{3}{8}$,
$c=\frac{1}{7}$, ,, = ,, $\times\frac{3}{9}$,
$c=\frac{1}{8}$, ,, = ,, $\times\frac{3}{10}$,
$c=\frac{1}{9}$, ,, = ,, $\times\frac{3}{11}$,
$c=\frac{1}{10}$, ,, = ,, $\times\frac{3}{12}$,
$c=\frac{1}{100}$, ,, = ,, $\times\frac{3}{102}$.

When M=5, m=4, then if

$c=\frac{1}{2}$, Half-breeds = Pure-breeds $\times\frac{4}{5}$,
$c=\frac{1}{3}$, ,, = ,, $\times\frac{4}{6}$,
$c=\frac{1}{4}$, ,, = ,, $\times\frac{4}{7}$,
$c=\frac{1}{5}$, ,, = ,, $\times\frac{4}{8}$,
$c=\frac{1}{6}$, ,, = ,, $\times\frac{4}{9}$,
$c=\frac{1}{7}$, ,, = ,, $\times\frac{4}{10}$,
$c=\frac{1}{8}$, ,, = ,, $\times\frac{4}{11}$,
$c=\frac{1}{9}$, ,, = ,, $\times\frac{4}{12}$,
$c=\frac{1}{10}$, ,, = ,, $\times\frac{4}{13}$,
$c=\frac{1}{100}$, ,, = ,, $\times\frac{4}{103}$,
$c=\frac{1}{1000}$, ,, = ,, $\times\frac{4}{1003}$.

TABLE V.

When $M=10$,	and $m=9$;	$m=8$;	$m=7$;	$m=6$;	$m=5$;	$m=4$;	$m=3$;	$m=2$;	$m=1$.
If $c=\frac{1}{2}$, then Half-breeds = Pure-breeds ×	$\frac{9}{10}$	$\frac{8}{10}$	$\frac{7}{10}$	$\frac{6}{10}$	$\frac{5}{10}$	$\frac{4}{10}$	$\frac{3}{10}$	$\frac{2}{10}$	$\frac{1}{10}$
If $c=\frac{1}{3}$, H = P ×	$\frac{9}{11}$	$\frac{8}{12}$	$\frac{7}{13}$	$\frac{6}{14}$	$\frac{5}{15}$	$\frac{4}{16}$	$\frac{3}{17}$	$\frac{2}{18}$	$\frac{1}{19}$
If $c=\frac{1}{4}$, H = P ×	$\frac{9}{12}$	$\frac{8}{14}$	$\frac{7}{16}$	$\frac{6}{18}$	$\frac{5}{20}$	$\frac{4}{22}$	$\frac{3}{24}$	$\frac{2}{26}$	$\frac{1}{28}$
If $c=\frac{1}{5}$, H = P ×	$\frac{9}{13}$	$\frac{8}{16}$	$\frac{7}{19}$	$\frac{6}{22}$	$\frac{5}{25}$	$\frac{4}{28}$	$\frac{3}{31}$	$\frac{2}{34}$	$\frac{1}{37}$
If $c=\frac{1}{6}$, H = P ×	$\frac{9}{14}$	$\frac{8}{18}$	$\frac{7}{22}$	$\frac{6}{26}$	$\frac{5}{30}$	$\frac{4}{34}$	$\frac{3}{38}$	$\frac{2}{42}$	$\frac{1}{46}$
If $c=\frac{1}{7}$, H = P ×	$\frac{9}{15}$	$\frac{8}{20}$	$\frac{7}{25}$	$\frac{6}{30}$	$\frac{5}{35}$	$\frac{4}{40}$	$\frac{3}{45}$	$\frac{2}{50}$	$\frac{1}{55}$
If $c=\frac{1}{9}$, H = P ×	$\frac{9}{17}$	$\frac{8}{24}$	$\frac{7}{31}$	$\frac{6}{38}$	$\frac{5}{45}$	$\frac{4}{52}$	$\frac{3}{59}$	$\frac{2}{66}$	$\frac{1}{73}$
If $c=\frac{1}{10}$, H = P ×	$\frac{9}{18}$	$\frac{8}{26}$	$\frac{7}{34}$	$\frac{6}{42}$	$\frac{5}{50}$	$\frac{4}{58}$	$\frac{3}{66}$	$\frac{2}{74}$	$\frac{1}{82}$
If $c=\frac{1}{100}$, H = P ×	$\frac{9}{108}$	$\frac{8}{206}$	$\frac{7}{304}$	$\frac{6}{402}$	$\frac{5}{500}$	$\frac{4}{598}$	$\frac{3}{696}$	$\frac{2}{794}$	$\frac{1}{892}$
If $c=\frac{1}{1000}$, H = P ×	$\frac{9}{1008}$	$\frac{8}{2006}$	$\frac{7}{3004}$	$\frac{6}{4002}$	$\frac{5}{5000}$	$\frac{4}{5998}$	$\frac{3}{6996}$	$\frac{2}{7994}$	$\frac{1}{8992}$

Observations on Table V.

This mathematical analysis of the effects of Positive Segregation and Segregate Fecundity when co-operating brings distinctly into view several important relations.

1st. Incomplete forms of Segregation, that avail little or nothing in preventing a form from being absorbed in the course of time, become very efficient when strengthened by moderate degrees of mutual sterility. Take, for instance, the line of the table in which $c=\frac{1}{100}$. If 1 in every 100 unions is a cross with some other form, the form will in time be overwhelmed, unless other causes come in to counteract; but here we see that, if Segregate Fecundity occurs in the ratio of 10 to 9, the pure form becomes 12 times as numerous as the half-breeds; and if in the ratio of 10 to 5, it becomes 100 times as numerous.

2nd. Again, if we take the proportional differences between the different terms of the top line opposite $c=\frac{1}{2}$, we shall find them very unlike the differences that appear in the bottom line opposite $c=\frac{1}{1000}$. In the former the first term is 9 times as large as the last; while in the latter the first term is more than 80 times as large as the last. This shows that when Segregation is intense, differences in the degree of Segregate Fecundity produce greater contrasts than the same differences do when the Segregation is slight.

3rd. A similar distinction is found when we compare the right-hand column with the left-hand column. The smallest term in the former is to the largest term in the same column as 1 to 899, while in the left-hand column the greatest difference is as 1 to 100. This shows that when Segregate Fecundity is strongly developed, differences in the degrees of Segregation produce greater contrasts than the same differences produce when the Segregate Fecundity is but slightly developed.

4th. Once more let us consider the relations to each other of the four terms that stand in the upper left-hand corner of the table. Suppose that of some one variety of a plant species, characterized by Prepotential Segregation and Segregate Fecundity, we have occurring in equal numbers four variations whose relations to other varieties are indicated by the figures given in these four terms, while in their relations to each other they are completely fertile and not Segregated. Which variation will leave the greatest number of pure offspring, that is the greatest number of offspring belonging to the one variety to which the four variations alike belong? Evidently the variation represented by the fraction $\frac{8}{12}$ will have the greatest influence on the following generation. But as the supposed conditions allow of exact computation, let us look at the problem a little closer. If each variation numbers say a thousand individuals, then the number of each that will breed true will be as follows:—Of the one represented by $\frac{9}{10}$, 526 will breed true and 474 will cross,

$\frac{9}{11}$,	550	„	450	„
$\frac{8}{10}$,	555·5	„	444·5	„
$\frac{8}{12}$,	600	„	400	„

And the next generation of each kind will be as follows: multiplying the pure parents by 10, and the hybrid parents by 8 or 9, according to the value of m, we have of those represented by

$\frac{9}{10}$,	pure offspring	5260,	hybrids	4266,
$\frac{9}{11}$,	„	5500,	„	4050,
$\frac{8}{10}$,	„	5555,	„	3556,
$\frac{8}{12}$,	„	6000,	„	3200.

There can, therefore, be no doubt that under such conditions the average Prepotential Segregation and Segregate Fecundity of the next generation will be considerably advanced, and so with each successive generation till the average of the Pure forms is represented by the fraction $\frac{8}{12}$, and is surrounded by a circle of variations, of which one will be represented by the fraction $\frac{7}{18}$. And from this new point continuous advance will be made toward ever higher and higher grades of Segregation and Segregate Fecundity; though of course the process will be subject to antagonisms and limitations arising from the principles of Self-accumulating Vigour and Self-accumulating Adaptation. Let it, however, be carefully noted that we have in this process the manifestation of a new principle, for it rests not only on Self-accumulating Positive Segregation but on Self-accumulating Segregate Fecundity.

TABLE VI.

Formula for Segregation, Segregate Fecundity, and Segregate Vigour, giving the Proportion of Half-breeds to Pure-breeds. (Constructed from Table III., according to rule 3.)

Pure-breeds.		*Half-breeds.*
A	Initial number.	
$A(MV-MVc)$.	1st generation.	$Amvc$.
$A(MV-MVc)^2$.	2nd generation.	$Amvc(1-2c)mv+Amvc(MV-MVc)$.
$A(MV-MVc)^3$.	3rd generation.	$Amvc((1-2c)mv)^2+Amvc(MV-MVc)(1-2c)mv+Amac(MV-MVc)^2$.
$A(MV-MVc)^4$.	4th generation.	$Amvc((1-2c)mv)^3+Amvc(MV-MVc)((1-2c)mv)^2+Amvc(MV-MVc)^2(1-2c)mv+Amvc(MV-MVc)^3$.
		$=Amvc(MV-MVc)^3\left(\frac{((1-2c)mv)^3}{(MV-MVc)^3}+\frac{((1-2c)mv)^2}{(MV-MVc)^2}+\frac{((1-2c)mv)}{(MV-MVc)}+\frac{(MV-MVc)^3}{(MV-MVc)^3}\right)$.
$A(MV-MVc)^{n-1}$	$n-1$th generation.	
$A(MV-MVc)^n$	nth generation.	$Amvc(MV-MVc)^{n-1}\left(\left(\frac{(1-2c)mv}{MV-MVc}\right)^{n-1}+\ldots+\left(\quad\right)^3+\left(\frac{(1-2c)mv}{MV-MVc}\right)^2+\frac{(1-2c)mv}{MV-MVc}+1\right)$.

nth generation of Pure-breeds $=A(MV-MVc)^{n-1}\times(MV-MVc)$; and therefore $\frac{\text{Half-breeds}}{\text{Pure-breeds}}=\frac{mvc}{MV-MVc}\left(1+\frac{(1-2c)mv}{MV-MVc}+\ .\ .\ .\ \right)$.

In the above formula, V = Vigour of Pure-breeds expressed by a fraction that gives the proportion of each generation that grow to maturity and propagate, v = the vigour of the Half-breeds expressed in the same way.

TABLE VII.

Formula for Segregation, Segregate Fecundity, and Segregate Vigour, giving the Proportion of the Three-quarter-breeds to the Pure-breeds.

T=the number of Three-quarter-breeds; m'=Ratio of Fertility for the same; v', a fraction giving the proportion of the Three-quarter-breeds that come to maturity. H=the number of Half-breeds. P=the number of Pure-breeds.

Turning to Table I., we find that the Three-quarter-breeds of each generation are the offspring of $\frac{1}{10}$ (or c) of the previous generation of Half-breeds who consort with an equal number of Pure-breeds, plus the descendants of previous generations of Three-quarter-breeds in as far as they breed with each other. Commencing our computation with the nth generation we know from Table VI., that the previous generation of Pure-breeds $=A\,(MV-MVc)^{n-1}$, and the Half-breeds of the same generation $=A(MV-MVc)^{n-1}\times\frac{H}{P}$; $\frac{H}{P}$ being the Ratio in which Half-breeeds stand to Pure-breeds, which is obtained as shown in Tables IV., V., and VI.; and c of this number will consort with an equal number of Pure-breeds, making $A(MV-MVc)^{n-1}\times\frac{H}{P}\,2c$ parents in the $n-1$th generation, that will produce $m'v'$ times that number of Three-quarter-breed offspring of the nth generation that will grow to maturity, Starting with this number in the nth generation, and pursuing the same method as was used in constructing Table III., we obtain the following series:—

Three-quarter-breeds.

$$n\text{th generation} = A(MV-MVc)^{n-1}\frac{H}{P}2c\,m'v'.$$

$$(n+1)\text{th generation} = A(MV-MVc)^{n-1}\frac{H}{P}2c\,m'v'\times(1-2c)m'v'+A(MV-MVc)^{n}\frac{H}{P}2c\,m'v'.$$

$$(n+2)\text{th generation} = A(MV-MVc)^{n-1}\frac{H}{P}2c\,m'v'\Big((1-2c)\,m'v'\Big)^{2}+A(MV-MVc)^{n}\frac{H}{P}2c\,m'v'\Big((1-2c)\,m'v'\Big)+A(MV-MVc)^{n+1}\frac{H}{P}2c\,m'v'.$$

$$(n+n)\text{th generation} = A(MV-MVc)^{n-1}\frac{H}{P}2c\,m'v'(MV-MVc)^{n}\left(\left(\frac{(1-2c)\,m'v'}{MV-MVc}\right)^{n}+\ldots+\left(\frac{(1-2c)\,m'v'}{MV-MVc}\right)^{2}+\left(\frac{(1-2c)\,m'v'}{MV-MVc}\right)^{1}+\left(\frac{MV-MVc}{MV-MVc}\right)^{n}\right).$$

In the $(n+n)$th generation, $P=A(MV-MVc)^{n+n}$; and therefore $\frac{T}{P}=\frac{\frac{H}{P}2c\,m'v'}{MV-MVc}\left(1+\left(\frac{(1-2c)m'v'}{MV-MVc}\right)^{1}+\Big(\quad\Big)^{2}+\Big(\quad\Big)+\Big(\quad\Big)^{n}\right).$

TABLE VIII.

Simplified Formulas, giving the Proportions in which Half-breeds and Three-quarter-breeds stand to Pure-breeds when we have both Segregate Fecundity and Segregate Vigour.

From Table VI. we learn that

$$\frac{H}{P}=\frac{mvc}{MV-MVc}\times\left(1+\frac{(1-2c)mv}{MV-MVc}+\ \ldots\right).$$

When the numerator, $(1-2c)mv$, is less than the denominator, $MV-MVc$, the sum of the whole series within the brackets may be obtained in accordance with the formula $S=\frac{a}{1-q}$, in which $S=$ the sum of the series, $a=$ the first term, and $q=$ the constant multiplier.

$$\therefore\ \frac{H}{P}=\frac{mvc}{MV-MVc}\times\frac{1}{1-\frac{(1-2c)mv}{MV-MVc}}$$

$$=\frac{mvc}{MV-MVc}\times\frac{MV-MVc}{MV-MVc-mv+2mvc}$$

$$=\frac{mvc}{MV-mv+(2mv-MV)c}.\ \ \ldots\ldots\ \ \text{(Formula 1)}$$

Applying the same method to the formula in Table VII., we find that

$$\frac{T}{P}=\frac{H}{P}\times 2\times\frac{m'v'c}{MV-m'v'+(2m'v'-MV)c}.$$

$$\therefore\ \frac{T}{P}=\frac{H}{P}\times\frac{2m'v'c}{MV-m'v'+(2m'v'-MV)c};\ \ \ldots\ldots\ \ (2)$$

and

$$\frac{T}{H}=\frac{2m'v'c}{MV-m'v'+(2m'v'-MV)c}.\ \ \ldots\ldots\ \ (3)$$

If $M=10$, $m=5$, $m'=5$, $V=\frac{1}{9}$, $v=\frac{1}{10}$, $v'=\frac{1}{10}$, $c=\frac{1}{10}$,

then $\frac{H}{P}=\frac{\frac{5}{100}}{\frac{10}{9}-\frac{5}{10}+\left(\frac{10}{10}-\frac{10}{9}\right)\frac{1}{10}}=\frac{\frac{5}{100}}{\frac{100}{90}-\frac{45}{90}-\frac{1}{90}}=\frac{\frac{5}{100}}{\frac{54}{90}}=\frac{450}{5400}=\frac{9}{108}=\frac{1}{12}$;

and (as $m=m'$, and $v=v'$)

$$\frac{T}{H}=2\frac{H}{P}=2\tfrac{1}{12}=\tfrac{1}{6};\ \text{and}\ \frac{T}{P}=\frac{H}{P}\times\frac{T}{H}=\tfrac{1}{12}\times\tfrac{1}{6}=\tfrac{1}{72}.$$

If $M=10$, $m=10$, $m'=10$, $V=\frac{1}{9}$, $v=\frac{1}{90}$, $v'=\frac{1}{90}$, $c=\frac{1}{10}$,

then $\frac{H}{P}=\frac{\frac{1}{90}}{\frac{10}{9}-\frac{10}{90}+\left(\frac{20}{90}-\frac{10}{9}\right)\frac{1}{10}}=\frac{\frac{1}{90}}{\frac{100}{90}-\frac{10}{90}+\frac{2}{90}-\frac{10}{90}}=\frac{1}{82}$;

and $\frac{T}{H}=\frac{2}{82}=\frac{1}{41}$; and $\frac{T}{P}=\frac{H}{P}\times\frac{T}{H}=\frac{1}{3362}$.

In this latter case, where the Vigour of Hybrids is $\frac{1}{10}$ that of Pure-breeds, while their Fecundity is equal to that of Pure-breeds, we find $\frac{H}{P}=\frac{1}{82}$, which is the same result as that given in the 8th line of the last column of Table V., where the Fecundity of cross unions and of Hybrids is $\frac{1}{10}$ that of Pure-breeds, while their Vigour is equal.

The Influence of Segregate Vigour.

I think we may say we have here come in sight of one form of the still wider fourfold law already mentioned; for on the same principle that Segregate Fecundity increases when once allied with partial Segregation in vigorous forms, Segregate Vigour must also tend to increase when brought into the same alliance; and I believe it will be found that there is a similar principle tending to the self-accumulation of Segregate Adaptation.

At the point where they both arise, that is during the period that immediately follows the act of impregnation, it is difficult to distinguish between the two principles, and the mortality of the hybrid embryo before birth, or before it leaves the egg, may be conveniently classed as Segregate Fecundity. *

Though the two principles are so closely related, it would be a great mistake not to distinguish them; for there is no close correspondence between the degrees in which the two qualities occur in the relations of individuals or varieties; and in some cases we find Segregate Fecundity associated with Integrate Vigour. The mule, though absolutely sterile, possesses vigour equal, if not superior, to that of either parent. In the record of experiments given by Darwin in 'Cross- and Self-Fertilization in the Vegetable Kingdom' mention is made of certain species in which self-fertilized flowers are more fertile than the cross-fertilized, while the plants produced from the crossed seed are the more vigorous; and of other species in which cross-fertilized flowers are by far the most productive, while the plants produced from the crossed seed are neither taller nor heavier than the self-fertilized.† In the same work the common pea (*Pisum sativum*), the common tobacco (*Nicotiana tabacum*), and *Canna Warscewiczi* are shown to be more vigorous when raised from self-fertilized seed than when raised from seed crossed with other individuals of the same strain; but in the case of the tobacco and the pea, great increase of vigour is produced by a cross with a slightly different variety while the fertility is increased but little if any.

But the most interesting of all his experiments as bearing on the subject of Segregate Vigour, is given in the history of " *The Descendants of the self-fertilized Plant, named* Hero, *which appeared in the Sixth Self-fertilized Generation of* Ipomœa purpurea.' "A cross between the children of *Hero* did not give to the grandchildren any advantage over the self-fertilized grandchildren raised from the self-fertilized children." "And, what is far more remarkable, the great-grandchildren, raised by crossing the grandchildren with a fresh stock, had no advantage over either the intercrossed or the self-fertilized great-grandchildren. It thus appears that *Hero* and its descendants differed in constitution in an extraordinary manner from ordinary plants of the same species." "If we look to the [ordinary] plants of the ninth generation in table x., we find that the intercrossed plants [of the same stock] were in height to the self-fertilized as 100 to 79, and in fertility as 100 to 26; whilst the Colchester-crossed plants [raised by crossing with a fresh stock] were in height to the intercrossed as 100 to 78, and in fertility as 100 to 51."* The Colchester-crossed plants were therefore in height to the self-fertilized as 1 to ·78 × ·79, or as 1000 to 616, and in fertility as 1 to ·51 × ·26, or as 1000 to 133; while the self-fertilized descendants of *Hero* when crossed with the same fresh stock not only had no advantage over those that had been continuously self-fertilized for nine generations, but, as the details of the experiment show, the advantage was on the side of the plants raised from the self-fertilized seed. The experiment was conducted under conditions decidedly unfavourable for the production of healthy plants; but, as it is usually found that the superiority of crosses between varieties is most clearly brought to light when the competitors are subjected to unfavourable circumstances, it seems to furnish even stronger evidence of Segregate Vigour being occasionally produced in the earliest stages of divergent evolution, than would have been furnished if the same degree of superiority in the self-fertilized plants had been obtained under a less severe test. As the case is of unusual interest, I give the details as recorded by Darwin:—

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* See 'Origin of Species,' 6th edition, p. 249. † See pages 322-329.

"Several flowers on the self-fertilized grandchildren of *Hero* in table xvi. were fertilized with pollen from the same flower; and the seedlings raised from them (great-grandchildren of *Hero*) formed the ninth self-fertilized generation. Several other flowers were crossed with pollen from another grandchild, so that they may be considered as the offspring of brothers and sisters, and the seedlings thus raised may be called the intercrossed great-grandchildren. And, lastly, other flowers were fertilized with pollen from a distinct stock, and the seedlings thus raised may be called the Colchester-crossed great-grandchildren. In my anxiety to see what the result would be, I unfortunately planted the three lots of seeds (after they had germinated on sand) in the hothouse in the middle of winter, and in consequence of this the seedlings (twenty in number of each kind) became very unhealthy, some growing only a few inches in height, and very few to their proper height. The result, therefore, cannot be fully trusted; and it would be useless to give the measurements in detail. In order to strike as fair an average as possible, I first excluded all the plants under 50 inches in height, thus rejecting all the most unhealthy plants. The six self-fertilized thus left were on an average 66·86 inches high, the eight intercrossed plants 63·2 high, and the seven Colchester-crossed 65·37 high; so that there was not much difference between the three sets, the self-fertilized plants having a slight advantage. Nor was there any great difference when only the plants under 36 inches in height were excluded. Nor, again, when all the plants, however much dwarfed and unhealthy, were included.

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* 'Cross- and Self-Fertilization,' pp. 47, 60, 61.

"In this latter case the Colchester-crossed gave the lowest average of all; and if these plants had been in any marked manner superior to the other two lots, as from my former experience I fully expected they would have been, I cannot but think that some vestige of such superiority would have been evident, notwithstanding the very unhealthy condition of most of the plants. No advantage, as far as we can judge, was derived from intercrossing two of the grandchildren of *Hero*, any more than when two of the children were crossed. It appears therefore that *Hero* and its descendants have varied from the common type, not only in acquiring great power of growth and increased fertility when subjected to self-fertilization, but in not profiting from a cross with a distinct stock; and this latter fact, if trustworthy, is a unique case, as far as I have observed in all my experiments." *

Let us now consider for a moment what must be the result when such a variation occurs in a wild species subject to the ordinary conditions of competition. In the first place, it would gradually prevail over other representatives of the same local stock, both by its more vigorous growth and by its greater fertility, especially in the case of flowers that failed of securing a cross. And afterwards, when it came into competition with the equally adapted variety from which it was partially protected by Segregate Vigour, it would neither be driven out nor lose its separate existence in a commingled race. It will be observed that we have in such a case Local, Germinal, and Floral Segregation, each producing partial effects which are enhanced by the Segregate Vigour. In order to bring out the relation of these factors to each other, let us assume definite values for each. Let us suppose that $\frac{3}{10}$ of the flowers are self-fertilized, $\frac{3}{10}$ are fertilized with pollen from another flower of the same plant, $\frac{3}{10}$ are fertilized with pollen from other plants of the same new variety, and $\frac{1}{10}$ are fertilized with pollen from the older variety occupying contiguous areas. Therefore the sum of the segregating influences, which is called the "Ratio of pure breeding," and is represented by R in Table II., equals $\frac{9}{10}$; and the "Ratio of cross-breeding," represented by c in all the tables, equals $\frac{1}{10}$. Again, let us suppose that the fertility of the pure breeds is the same as that of the half-breeds, but that the superior vigour of the former is such that any one of the pure seeds has twice as good a chance of germinating, growing to maturity, and producing seed as any one of the crossed seeds. The general effect on the final result will in that case be the same as if the "Ratio of increase for the pure unions" (which I call M) equalled 10, while the "Ratio of increase for the cross unions" (which I call m) equalled 5. Turning now to Table V., we can easily find the ratio in which the number of pure-breeds will stand to the half-breeds, if the conditions continue long; for in the column in which m equals 5 and in the line marked $c = \frac{1}{10}$ we find $\frac{5}{50}$, which means that the half-breeds will equal the pure-breeds multiplied by $\frac{5}{50}$, or by $\frac{1}{10}$.

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* 'Cross- and Self-Fertilization in the Vegetable Kingdom,' pp. 50, 61.

Segregate Vigour and Segregate Fecundity between Human Races.

My attention has recently been called to the following facts relating to the Japanese and Aino races, who have for many centuries met under circumstances favourable for interfusion without any apparent effect of this kind. I quote from 'Memoirs of the Literature College, Imperial University of Japan,' No. 1: "The Language, Mythology, and Geographical Nomenclature of Japan viewed in the Light of Aino Studies," by Basil Hall Chamberlain, p. 43:—

"With what logic, it may be urged, do you invite us to accept a great extension of the Aino race in early Japan, when it is a physiological fact, vouched for by so high an authority as Dr. Baelz, that there is little or no trace of Aino blood in the Japanese people? In reply to this some would perhaps quote such examples as New England, whence the Indians have vanished, leaving nought behind them but their place-names. In Japan, however, the circumstances are different from those of New England. There has undoubtedly been constant intermarriage between the conquerors and the native race upon the Aino border. We can infer this from history. Those who have travelled in Yezo know it by personal experience to-day. Nevertheless, these intermarriages may well consist with the absence of any trace of Aino blood in the population. As a matter of fact, the Northern Japanese, in whose veins there should be most Aino blood, are no whit hairier than their compatriots in Central and Southern Japan. Anyone may convince himself of this by looking at the coolies (almost all Nambu or Tsugaru men) working in the Hakodate streets during the summer months, when little clothing is worn. But the paradox is only on the surface. The fact is that the half-castes die out—a fate which seems, in many quarters of the world, to follow the miscegenation of races of widely divergent physique. That this is the true explanation of the phenomenon was suggested to the present writer's mind by a consideration of the general absence of children in the half-breed Aino families of his acquaintance. Thus, of four brothers in a certain village where he staid, three have died leaving widows without male children, and with only one or two little girls between the three. The fourth has children of both sexes; but they suffer from affections of the chest and from rheumatism. Mr. Batchelor, whose opportunities for observation have been unusually great, concurs in considering this explanation as sufficient as it is simple. There are scores of mixed marriages every year. There are numerous half-breeds born of these marriages. But the second generation is almost barren; and such children as are born—whether it be from two half-breed parents, or from one half-breed parent and a member of either pure race, are generally weakly. In the third or fourth generation the family dies out. It may be added that the half-breeds have a marked tendency to baldness, and that their bodies are much less hairy than those of the genuine

Ainos. This fact has doubtless helped to cause the divergence of opinion with regard to Aino hairiness. For the comparatively smooth half-breeds usually speak Aino, dress Aino-fashion, and are accounted to be Ainos, so that travellers are likely to be misled, unless constantly on their guard. There seem to be half-breeds in all the villages whither Japanese pedlars and fishermen have penetrated. There have therefore probably, at some time or other, been half-breeds in every portion of Japan where the two races have come in contact."

If these two races were equal in civilization and in natural adaptation to the environment, or if one race was specially adapted to mountain life and the other to life by the sea-shore, it seems probable that they might permanently occupy adjoining countries without losing any of their distinctive characteristics. Broca, after careful collation of all the information that could be gathered from the publications of travellers and historians, reaches the conclusion "that alliances between the Anglo-Saxon race and the Australians and Tasmanians are but little prolific; and that the mulattoes sprung from such intercourse are too rare to have enabled us to obtain exact particulars as to their viability and fecundity."* I have no means of knowing whether later investigations in Australia and other parts of the world have thrown fuller light on the mutual fertility or sterility of the more divergent human races, but I am inclined to think that the interest in the subject has declined since Darwin has shown that such data can never afford proof that the different races of man are not descended from common ancestry. There are, however, signs that a renewed interest in the subject is being awakened through the realization that it has a direct bearing on the theory of the origin of species.

Impregnational Segregation a Cause of Divergence in both its Earlier and Later Stages.

As we have already seen, the negative factors† Segregate Vigour and Segregate Fecundity would tend to produce extinction if not associated with positive forms of Segregation. But in the case of organisms whose fertilizing elements are distributed by wind and water, the qualities that produce these negative forms of Segregation are usually accompanied by those that produce Prepotential Segregation, which is in an important degree positive. But even Prepotential Segregation, when produced by mutual incompatibility between a few individuals and a numerous parent stock, depends for its continuance and development on Local, Germinal, or Floral Segregation, partially securing the intergeneration of the few that are mutually compatible. On the one hand, Impregnational Segregation depends on some degree of Local, Germinal, or Floral Segregation which is a constant feature in most species; but, on the other hand, not only do these initial forms of Positive Segregation fail of producing any permanent divergence till associated with Impregnational Segregation, but the more effective forms of Positive Segregation, such as Industrial, Chronal, Fertilizational, Sexual, and Social Segregation, often depend on Impregnational Segregation, inasmuch as the divergence of endowments which produces these depends on Impregnational Segregation. Moreover, in all such cases, increasing degrees of diversity in the forms of adaptation, and consequently of diversity in the forms of natural selection, must also depend upon these negative factors, which in their turn depend on the weak, initial forms of Positive Segregation.

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* See 'Phenomena of Hybridity in the Genus *Homo*.' By Paul Broca. English translation, published for the Anthropological Society of London by Longman, Green, Longman, and Roberts (1864), pp. 45–60.

† For a definition of Negative Segregation see page 238 of this paper.

Divergent evolution always depends on some degree of Positive Segregation, but not always on Negative Segregation. Under Positive Segregation of a rigorous form (as, for example, complete Geographical Segregation), considerable divergence may result without any sexual incompatibility. Darwin has shown, by careful experiments, that *Integrate* Vigour and Fecundity is the relation in which the varieties of one species usually stand to each other. This fact does not, however, prove that the more strongly divergent forms, called species, which are prevented from coalescing by Segregate Vigour and Fecundity, did not acquire some degree of this latter character before any permanent divergence of form was acquired. Their having acquired this segregating characteristic may be the very reason why their forms are now so decidedly different, for without it they would have been swallowed up by the incoming waves of intergeneration. Again, we must remember that forms only moderately divergent are habitually classed as different species if they are separated by Segregate Vigour and Fecundity (that is by some degree of mutual sterility), unless observation shows that they are of common descent. These two considerations sufficiently explain why the varieties of one species are so seldom reported as mutually infertile. Notwithstanding this, the experiments of Gartner and of Darwin, already referred to at length, seem to show that Segregate Fecundity and Vigour may arise between varieties that spring from one stock. In view of these cases, we must believe that in the formation of some, if not many, species, the decisive event with which permanent divergence of allied forms commences is the intervention of Segregate Fecundity or Vigour between these forms. Positive Segregation, in the form of Local, Germinal, or Floral Segregation producing only transitory divergences, always exists between the portions of a species that has many members, but as it does not directly produce the Negative Segregation which is, in such cases, the necessary antecedent of permanent divergence, we cannot, in accordance with the usage of language, call it *the* cause of the permanent divergence. Moreover, though it may be in accordance with ordinary language to call the Negative Segregation, which is the immediate antecedent of the permanent divergence, the cause of the same, it will be more correct to call the coincidence of the Negative and Positive Segregations the cause, and still more accurate to say that the whole range of vital activities (when subjected to the limitations of any sexual incompatibility that corresponds in the groups it separates to some previous but ineffectual Local, Germinal, or Floral Segregation), will produce permanent divergence.

In many cases not only is the entrance of Impregnational Segregation the cause of the commencement of permanent divergence, but its continuance is the cause of the continuance of the divergence. The clearest illustration of this is found in the case of plants that are fertilized by pollen that is distributed by the wind. All the higher, as well as the lower, groups of such plants would rapidly coalesce if each grain of pollen was capable of producing fertilization, with equal certainty, promptness, and efficiency, on whatever stigma it might fall. We may also be sure that, with organisms that depend upon water for the distribution of their fertilizing elements, Impregnational Segregation is an essential factor in the development of higher as well as of lower taxonomic groups.

It is important to observe that, in the cases under consideration, *the inferior fertility or vigour resulting from the crossing* of the incompatible forms is as truly a cause of divergence as *the inferior opportunity for crossing* which from the first existed between the members occupying different localities or between the flowers growing on different trees of the same species. The former has been called Negative, and the latter Positive, Segregation, not for the sake of distinguishing different grades of efficiency, but for the sake of indicating the different methods of operation in the two classes of Segregation.

(*c*) INSTITUTIONAL SEGREGATION.

Institutional Segregation is the Reflexive form of Rational Segregation. It is produced by the rational purposes of man embodied in institutions that prevent free intergeneration between the different parts of the same race.

As the principal object of the present paper is to call attention to the causes of Segregation acting independently of effort and contrivance directed by man to that end, it will be sufficient to enumerate some of the more prominent forms under which Institutional Segregation presents itself, noting that some of these influences come in as supplemental to the laws of segregation already discussed, simply reinforcing by artificial barriers the segregations that have their original basis in nature. The chief forms that should be enumerated are National, Linguistic, Caste, Penal, Sanitary, and Educational Segregation; and if we had not already considered Industrial Segregation in the previous chapter, that might be added.

CONCLUDING REMARKS.

Besides Artificial and Institutional Segregation, which depend on the rational purpose of man, we have now considered numerous forms of Segregation, resting on no less than 18 groups of purely natural causes. Owing to the length of this paper I deem it wise to bring it to a close without discussing the laws that cooperate in intensifying the effects directly produced by the segregative causes already considered. As I have shown in Chapter II., Segregation is not simply the Independent Generation of the different sections of a species, but the Independent Generation of sections that differ; and though no one will believe that any two sections of a species are ever exactly equivalent, it is evident that the degrees of difference may be greater or less, and that whatever causes a greater difference in two sections that are prevented from intergenerating will also be a cause of increased Segregation.

It has been observed that some of the causes enumerated in this and the previous chapter are primarily separative, and that no one of those that are primarily segregative is at any one time segregative in regard to many classes of characters. As several forms of Segregation may co-operate in securing a given division of a species, and one form is superimposed upon another, the aggregate effect must be incalculably great; but we easily perceive that it may be indefinitely enhanced by causes producing increased divergence in the segregated branches. The causes which produce monotypic evolution when associated with Intergeneration must be equally effective in producing polytypic evolution when associated with Segeneration, whether in its separative or segregative forms. But the discussion of Intensive Segregation must be reserved for another occasion.

Believing that the study of Cumulative Segregation in its relations to the other factors of evolution will throw light on the origin of species far beyond what I have been able to elicit, I trust the subject will secure the attention of those who enjoy better opportunities than I do for carrying forward such investigations.

26 Concession, Osaka, Japan,
May 12, 1887.

APPENDIX.

Classified Table of Forms of Segregation.

A.

Environal Segregation.
- (*a*) Industrial Segregation.
  - Sustentational.
  - Defensive.
  - Nidificational.
- (*b*) Chronal Segregation.
  - Cyclical.
  - Seasonal.

(*c*) Spatial Segregation.
    Geographical.
    Local.
        Migrational.
        Transportational.
        Geological.
(*d*) Fertilizational Segregation.
(*e*) Artificial Segregation.

B.

Reflexive Segregation.
(*a*) Conjunctional Segregation.
    Social.
    Sexual.
    Germinal.
    Floral.
(*b*) Impregnational Segregation.
    Segregate Size.
    Segregate Structure.
    Prepotential Segregation.
    Segregate Fecundity.
    Segregate Vigour.
(*c*) Institutional Segregation.

C.

Intensive Segregation.
(*a*) Assimilational Intension.
(*b*) Stimulational Intension.
(*c*) Suetudinal Intension.
(*d*) Correlated Intension.
(*e*) Integrational Intension.
(*f*) Selectional Intension.
(*g*) Fecundal Intension.
(*h*) Eliminational Intension.

On some Ovicells of Cyclostomatous Bryozòa.

By ARTHUR WM. WATERS, F.L.S., F.G.S.

[Read 5th April, 1888.]

(PLATE XIV.)

FOR the determination of the Cyclostomatous Bryozoa the ovicells are certainly most important characters, and in many cases are undoubtedly of generic value; but how far this is universally the case we are not yet in a position to decide. It may, however, safely be said that the Cyclostomata will never be rescued from their present confusion until we are more fully acquainted with these receptacles. Though of such paramount importance, they are not known in a large majority of species. This is partly on account of insufficient search, but more from the fact that large numbers of specimens are often found without any ovicells; so that in some common species they are as yet unknown. For instance, ***Hornera concatennata***, Reuss, a fossil found abundantly in the Miocene of Italy, Germany, Austria, and Hungary, has, so far as we know, never furnished an ovicell.

It will thus be seen that with the Cyclostomata it is often the case that abundant material is necessary for true appreciation of the characters, and therefore it was a considerable disappointment that the results of the 'Challenger' Expedition were not richer in this respect. I am, however, now able to add figures of the ovicells of three species found by the 'Challenger,' one from 'Challenger' material, and two from specimens in my own collection from other localities.

HORNERA FISSURATA, *Busk*. (Pl. XIV. figs. 1, 3, 4, 7.)

Taking them in order: when, through the kindness of Mr. John Murray, I received two colonies of "*Idmonea fissurata*," Busk, from 'Challenger' "Station 320," near Monte Video, I was surprised to find a dorsal ovicell upon one, giving sufficient ground for removing it to *Hornera*; but the structure of both the front and back would have led me to do this independently of the ovicell.

As Miss Busk had kindly sorted and forwarded the specimens, I informed her what I had found; and she replied that she had also noticed them, and mounted some for the British Museum, and added that it was to be regretted that "there did not happen to be any among the rather numerous specimens selected for examination by Mr. Busk"; who would have placed it, she considered, under *Hornera* if he had noticed the ovicell.

In *Idmonea* I believe the ovicell is only known in *I. radians*, Lam., *I. atlantica*, Forbes, *I. gracillima*, Busk, *I. concava**, Reuss, *I. serpens*, L., *I. eboracensis*, Busk, *I. radicata*, Kirkpatrick; and in all is on the anterior surface; but both in *Idmonea* and *Hornera* the position may be axillary, or far away from the bifurcation; and the position in relation to the axils can seldom or never be looked upon as characteristic. I have before me a MS. list of 130 *Idmoneæ*, some of them synonyms, though all have been considered as separate species; but only in the few cases mentioned is the ovicell described. An ovicell has been figured by Hagenow as *Cœlophyma granulata* on "*Idmonea*" *lichenoides*, Goldf.; but I am not sure that this is a true *Idmonea*.

From a list of 74 species of *Hornera*, it seems that the ovicell is only known in *H. frondiculata*, Lam., *H. foliacea*, MacG., *H. violacea*, Sars (practically dorsal), *H. galeata*, Sm., *H. robusta*, MacG., *H. ramosa*, MacG., *H. lichenoides*, L.† Goldstein (Trans. Roy. Soc. Vict. 1881, pl. ii. figs. 6, 7, 8) has named a 'Challenger' specimen from Marion Island *H. subdubia*, with "ovicells"; but from the figure it might be *Hydrocorallina*. Reuss has described as *Cœlophyma striata* an ovicell which, as pointed out by Manzoni, probably belongs to *H. hippolyta*, Defr. In all these cases the ovicell is dorsal, forming a distinct chamber; and this is also the case in *Hornera fissurata*. In this last it is longitudinally ridged, and in the furrows are pits, giving, when not calcined, an areolated appearance.

The position and nature of the opening of the ovicell is most important, often, in fact, more so than the shape of the ovicell. The opening is, however, formed after the ovicell is complete, so that frequently this important character cannot be made out; and in my specimen I could not find any opening, but one of the lateral zoœcial tubes is much larger than usual, and looked as though this change was connected with the functions of the ovicell. I therefore wrote to Mr. Kirkpatrick, of the British Museum, explaining what I had seen in my specimens, and asked him if he would look at those in the Museum. He kindly did so at once, and wrote that he examined ten ovicells, "and found in each instance that the last one or two zoœcia of a series in proximity to an ovicell are not only enlarged, but considerably altered in direction. In eight instances the tube curved forwards and upwards so as to open on the anterior surface." In two the tubes opened laterally. "In every case the wide tube is to some extent connate to a zoœcial series; but in some cases the former curves away from the latter in such a way as to make the wide tube appear to be part of the ovicell, and not a metamorphosed zoœcium" *.

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* Not described; but a recent specimen from Naples has the ovicell as a raised chamber at the bifurcation. It nearly encloses one of the series, and the ovicellular opening is by the side of the series. In another specimen there is a slight central inflation between the series; but this does not seem to be mature.

† I find that *H. lichenoides*, L., occurs in Naples, together with *H. frondiculata*, and has an ovicell with a rib down the middle, as figured by Smitt and Alder, whereas Hincks figures a transverse rib. It has been looked upon as an exclusively northern form; but the 'Challenger' found it off Monte Video; and, as mentioned, it lives in the Mediterranean. Among the 'Challenger' material in Edinburgh I have since seen the ovicells on specimens from Simon's Bay. These have a central rib, and also a transverse one from the ovicelluiar opening to the median rib.

I have already referred (Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 255) to the fact that the ovicells of the Cyclostomata have the surface nearly always perforated with much more numerous pores than the rest of the zoarium. In the present case the ridges are narrower and the pits somewhat finer than on the rest of the dorsal surface; and at the base of these pits, which are sometimes spoken of as pores, there are several fine pores, whereas in the pits on the dorsal surface, except when elongated, there is but one pore at the base. It will thus be seen that in this case the pores on the ovicell are much more numerous than on the rest of the zoarium.

Figures (1 and 3) are given from calcined specimens of the front and back of the zoarium, and I consider that preparations should be thus made wherever there is available material; for figuring with all the organic integument is like taking a photograph of a lady with a thick veil down. Calcined specimens can be directly compared with fossils.

The anterior surface has large pores, or rather pits, following the lines of the zoœcia, with one or two pores at the base of the pit. The way in which the ornamented appearance is formed is shown more clearly in this species than in any other I have seen. At

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* In the 'Challenger' specimens in Edinburgh ovicells occur in a large number of cases, with a large lateral tube curving forwards.

the growing end the zoœcial tubes are more or less angular, and down each side there is a row of rather small pores (fig. 3); as growth proceeds, calcareous matter is added in ridges both on the front and back surfaces, and then these small pores are left at the bottom of the pits. I figured and referred to these pits in *Hornera frondiculata* in the Quart. Journ. Geol. Soc. vol. xl. p. 677, pl. xxx. fig. 8.

The external structure of the growing ends of the outside is the same as seen in the inside in other parts when broken down, or when sections are made. The position of the interzoœcial pores is often very characteristic, and can also sometimes be used in fossil species. These internal pores may be in parallel rows close together or far apart, and may be approximately regular or irregular; and the distance apart is a point of great importance; but as yet little attention has been given to these pores in published papers. An absolute regularity does not seem ever to occur; but the plan can very frequently be seen.

There is one structure which I am not able to explain. In the interior of the zoœcial tubes there are several protuberances projecting forwards (fig. 7), either short or half as long as the width of the zoœcial tubes, and much curved forwards. They do not seem to be the commencements of "closures," and whether they are used for attachments cannot be decided from my dried specimens. Although I have sections of a very large number of Cyclostomata, I have not come across anything of the kind before. It does not seem likely that it should be compared with the rays of *Entalophora intricaria*, *Lichenopora*, and *Heteropora* (see Quart. Journ. Geol. Soc. vol. xliii. p. 340, &c.); but both are as yet unexplained. In the coarsely pitted structure this species resembles *Idmonea radians*, Lam.; but the genus *Idmonea* usually has a finely punctured surface.

The zoœcia are arranged in very distinct series, suggesting at first *Idmonea*; but the serial arrangement is not uncommon in *Hornera*; for in *H. lichenoides* it occurs decidedly in some specimens, and in the fossil *H. concatenata*, Rss., and *H. serrata*, Rss. (non d'Orb., non Menegh.), it is very marked; again in *H. lichenoides* the amount to which the zoœcial tubes are exserted is variable, and no doubt this and *H. fissurata* are closely allied.

IDMONEA MENEGHINI, *Heller*. (Pl. XIV. fig. 2.)

The ovicell taking the place of one of the lateral series is a unique structure; and, so far as I am aware, nothing of the kind has before been found. The base is narrow, but the sac widens out, and then again becomes narrower; the surface has a few large oval pores, and the ovicellular opening is a raised tube at one upper corner. The zoœcial tubes spread out at the ends.

It is placed, with hesitation, under *I. Meneghini*, as there are only four zoœcia to a series; but Heller only figures four, and the number is not always constant in a colony. In a specimen from Naples, without an ovicell, of what I considered *I. Meneghini*, the zoœcial tubes do not spread out at the end in the same way; but sometimes a trace of this structure can be seen. The dorsal surface near the ends of the branches is finely punctured, but near the base there are larger openings. I have only the one specimen with ovicells.

IDMONEA IRREGULARIS, *Meneghini.* (Pl. XIV. figs. 5 and 6.)

This was found by the 'Challenger' off the Azores; and Mr. Busk (p. 14) says, "oœcial chamber?"

I have, however, previously (see Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 257, and Quart. Journ. Geol. Soc. vol. xl. p. 687) referred to the dorsal ovicell of *I. irregularis*; but as it has never been figured, a normal ovicell is given (fig. 5) and a short abnormal one (fig. 6).

The ovicellular aperture is wide, with a raised irregular funnel-shaped opening; but in the young ovicells the upper part is flat, sloping inwards. One colony has eight ovicells, and five of these are intact, without showing any opening; and from this we see how misleading this specimen alone would have been, as the young ovicells are without external orifices.

A somewhat similar ovicell occurs on *Filisparsa orakeiensis*, Stol. (*loc. cit.* p. 687).

IDMONEA MILNEANA, *d'Orb.* (Pl. XIV. fig. 8.)

I have already referred to the ovicell of *I. Milneana* (Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 256), and give a figure from a Capri specimen, and may repeat that the British Museum specimens of *I. notomala*, B., and *I. Milneana*, d'Orb., are so similar that they might be fragments of the same colony. The ovicell is figured from a rather broken-down specimen, and therefore there is some restoration of the zoœcial tubes.

EXPLANATION OF PLATE XIV.

Fig. 1. Anterior surface of *Hornera fissurata*, Busk, drawn from calcined specimen.
2. *Idmonea Meneghini*, Heller. Naples.
3. Dorsal surface (growing end) of *Hornera fissurata*, B.
4. Dorsal surface of *Hornera fissurata*, B., showing ovicell.
5. Normal ovicell of *Filisparsa irregularis*, Meneghini. Dorsal surface. Naples.
6. Short ovicell of *Filisparsa irregularis*, Menegh.
7. Section of zoœcial tubes of *Hornera fissurata*, B., showing interior projections.
8. *Idmonea Milneana*, d'Orb., from Capri.

Note.—I also found that in *Gephyrophora polymorpha*, B., dredged by the 'Challenger' from Simons Bay, there is an entirely concealed ovicell. It is a round sac quite free except at the border of the opening; whereas in other Chilostomata, so far as my experience goes, the wall of the ovicell is for a considerable part attached to the zoœcial walls.

On the Ovicells of some *Lichenoporæ*.

By Arthur Wm. Waters, F.L.S., F.G.S.

[Read 3rd May, 1888.]

(Plate XV.)

By *Lichenopora* I understand a genus with cancelli between the rays; but there are other discoid forms with the zoœcia arranged in radial series, so that the mode of growth is common to several genera. For instance, the fossil *Actinopora regularis*, d'Orb., does not seem to have any cancelli, and I cannot agree with my friend Mr. Hincks in placing it under *Lichenopora*, but should consider it *Multitubigera*.

Dr. Jullien* would take us back to the name *Disporella* of Gray, and points out the curious mistake that was made for so many years in calling this genus *Discoporella*, Gray; whereas *Discoporella* was a name given by d'Orbigny to some Chilostomata which would now be *Cupularia* or allied genera. The genus *Lichenopora* is, however, older than Gray's, and is now well established, so that I am unable to understand why Dr. Jullien wishes us to return to *Disporella*. On the other hand, another

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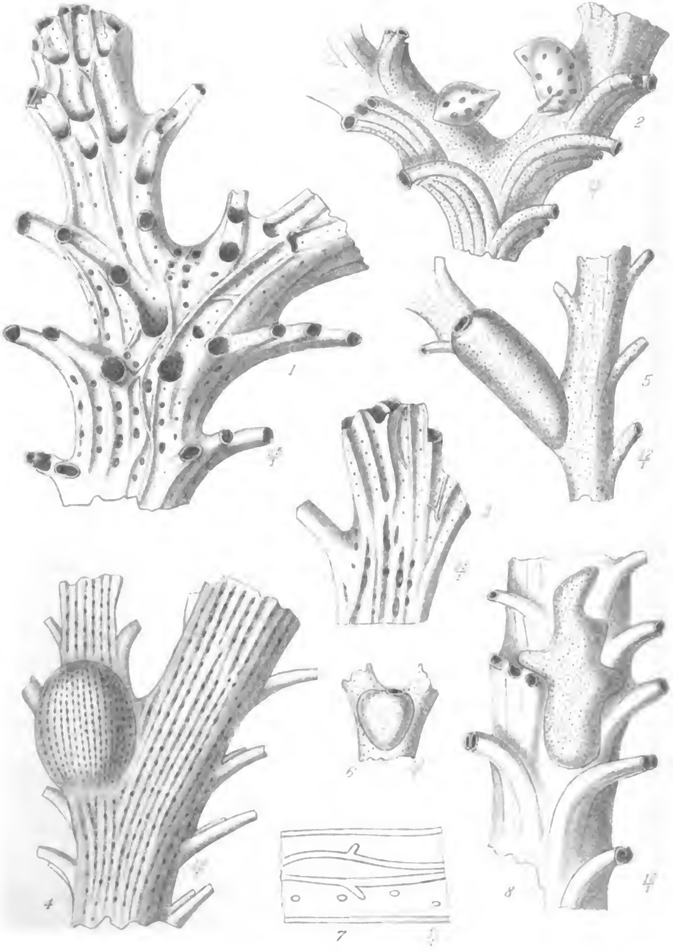
* Mission du Cap Horn: Bryozoaires.



A. W. Waters del.

R. [illegible] lith.

Imp. Camb. Sci. Inst. Co.

recent writer, Mr. Th. Marsson*, revives *Discocavea* and *Defrancia* for *Lichenopora*, though his *Defrancia* contains species which, according to what I have said above, cannot be placed with *Lichenopora*, and his *Discocavea* is entirely based upon the radii being uniserial; but this cannot be looked upon as a generic character, and even in specific determination must not be used with too much confidence, as there are some species where the rays are in parts uniserial, in others biserial.

In some species there are spines arising from various parts of the surface of the zoarium, but these do not appear to furnish constant characters; and, further, I have on one or two occasions called attention to the great variation to which the shape of the peristome is subject in different parts of the same colony; on the other hand, which side of the peristome is prolonged seems to be of considerable diagnostic importance.

The internal "rays" in the zoœcial tubes and cancelli should be more studied, and I should consider the denticulation of recent *Heteropora cervicornis*, d'Orb. (Journ. R. Micr. Soc. vol. ii. p. 392, pl. xv. figs. 9–11), *Lichenopora bullata*, MacG., *L. echinata*, MacG., and *L. pristis*, MacG., as the equivalents of the rays with knobs in *Entalophora intricaria*, B., *Lichenopora radiata*, Aud., *L. reticulata*, MacG., *L. Holdsworthii*, B., &c.

Further, the position of the connecting-pores in the interior walls of the zoœcia should be examined.

Having seen how many of the characters used for diagnosis are variable, it is quite clear that numerous species made on account of a difference in some unimportant character can never be recognized again, making a better acquaintance with this genus very desirable; and it seems that a knowledge of the ovicells may often assist us in more fully grasping the amount of variation caused by the conditions under which the colony grew, and may show the amount of variation in different parts of a colony. We are as yet unable to say how far the ovicells may be trusted for specific determination; but there is no doubt that they are for this purpose of value. Also as some species have been described without ovicells and some with, in cases where the author has not appreciated whether they were present or not, exact studies in both conditions are required. In so recent a book as Busk's 'Catalogue of the British Museum Polyzoa,' pt. iii., where 14 species are described, the ovicells are never mentioned, nor are they in the

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* Bryozoa der weissen Schreibkreide der Insel Rügen, 1887.

'Challenger' Report. A 'Challenger' specimen from Tristan da Cunha was submitted to me named *L. fimbriata*. This is *L. echinata* with an ovicell, so that the name *fimbriata* must be dropped

The ovicells sometimes occur as inflations over the central area, as in *L. grignonensis*, B. (see Ann. Mag. Nat. Hist. ser. 5, vol. xx. pl. vii. fig. 4), *L. novæ-zelandiæ*, B., *L. wanganuiensis*, Waters (Quart. Journ. Geol. Soc. vol. xliii. p. 346), *L. Holdsworthii*, B., *L. echinata*, B.; or it may be nearer to the edge, showing the ovicellular ducts as figured by Mr. Hincks in *Lichenopora radiata*.

Although now keenly on the look-out for ovicells, it is a very difficult study, which can progress but slowly and only be done satisfactorily with ample material collected from a few localities, and one cannot help feeling despair when trying to determine the *Lichenoporæ*; but it is a genus which, when understood, is perhaps more likely than any other to throw light upon the Cyclostomata generally and upon some fossil forms.

LICHENOPORA CALIFORNICA, *Busk*. (Pl. XV. fig. 1.)

Unicavea californica, *d'Orb. Pal. Franç.* p. 972.

Discoporella californica, *Busk*, *Cat. Mar. Poly.* pt. iii. p. 32, pl. xxx. fig. 5.

Specimens from Port Western (Victoria) given to me by Miss Jelly seem to be the species described by Mr. Busk; but as d'Orbigny's description might apply equally well to three or four species, it seems preferable to consider Mr. Busk as the author.

The radii are usually bi- or triserial, though in parts only uniserial, and in one specimen most of the rays are uniserial and only locally biserial; the interserial spaces have round or angular cells, but when these interserial cancelli are examined at a level below the surface they are usually seen to be round. The mouths of the cells are prolonged on the distal margin, namely, the side nearest to the border of the zoarium. Zoœcial tube about 0·06 mm. wide inside. When the ovicellular cover is removed the central area is seen to have large reticulated spaces. The upper part of the ovicell is formed by a finely perforated plate extending between the rays like the cogs of a wheel. There is a thick calcareous rim at the border of this area.

The thin calcareous border of the zoarium is not shown, as this is very variable in size, and probably of no specific value.

Loc. California (*Busk*); Port Western (Victoria).

LICHENOPORA ECHINATA, *MacG.* (Pl. XV. figs. 2, 3, 6.)

Discoporella echinata, *MacG. Trans. Roy. Soc. Vict.* vol. xx. p. 127, fig. 4.

Through Miss Jelly's kindness I have been able to examine a considerable number of specimens of *Lichenoporæ* from Victoria, and an abundant one is, I think, the *L. echinata* of MacGillivray. The zoœcia are irregularly arranged, the peristome is much produced on the proximal edge, namely, the margin nearest to the centre of the zoarium, sometimes with one process, sometimes divided into several; numerous fine spines usually grow from the zoœcial tubes as well as from the cancelli and the surface of the ovicell. The cancelli are angular with rounded corners, though when the tube is examined at some depth below the surface it is often seen to be round, and some of the cancelli may be called round, though that is not the usual character; the entire inner surface of the cancelli is denticulate. The ovicell is formed by an inflated crust covering all the central area of the zoarium, and, as shown in figure 6, it starts from numerous places, ultimately meeting in the centre: at first this crust is very thin, but in the mature condition is deeply pitted; the surface is then somewhat ribbed and there are numerous small pores at the base of the pits. In my previous paper to this Society (p. 277) I alluded to somewhat similar pits in *Hornera*.

As soon as the growth of the ovicell commences the basal reticulated cells of the central area are covered over by a thin pellicle with several perforations to each cancellus. Both the upper and under surface of the ovicell is shown in figure 6. Figure 3 is drawn from a specimen bent up at the two sides, and it is impossible to figure it satisfactorily, as it cannot all be seen in one focus.

The opening of the ovicell is a wide tube low down at the border of the inflation, directed horizontally, much in the same way as in *L. ciliata* (Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 263, pl. vii. fig. 5); but I have only seen the one ovicell of *L. ciliata* spreading among the zoœcial tubes, and these two forms seem so closely allied that I am in doubt as to the basis of their distinction.

In some specimens the zoœcia are slightly ridged, as in *L. grignonensis*. The spines from the zoœcial tubes are not constant, sometimes occurring in great abundance, in others there are very few or they may be entirely absent. Both in this and *L. pristis*, MacG., there is a semitransparent closure with a dull opaque disk in the centre, perforated in the middle. It seems probable that *L. pristis* and *L. echinata* are only the simple and confluent colonies of the same thing.

Loc. Victoria; Tristan da Cunha ('Challenger').

LICHENOPORA VICTORIENSIS, nom. nov. (Pl. XV. fig. 4.)

Discoporella reticulata, *MacGillivray, Trans. Roy. Soc. Vict.* vol. xx. p. 126, fig. 1.

There is already ***Lichenopora reticulata***, since Hagenow described a fossil as *Defrancia reticulata* (Bry. der Maast. Kreide, p. 43, pl. iv. fig. 3, non 4). Marsson has already shown that the description refers to fig. 3 and not to 4. It is possible that this may have been described under another name, but this is not certain; and I certainly cannot agree with Dr. Pergens, who would call it *diadema*, uniting the *Defrancia disticha*, Hag., *D. diadema*, Gold., and *D. reticulata*, Hag.

As Mr. MacGillivray describes it from Victoria, I would suggest the name ***L. victoriensis.***

This is one of those species in which without the ovicellular ducts it would be difficult to say whether there was an ovicell or not. The central area is covered by the ovicell, the covering of which is formed by large raised trabeculæ, within which there is a smaller reticulation formed by similar trabeculæ. There are spines with knobs from the walls of the trabeculæ, similar to those I described in *Lichenopora grignonensis* (Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 262, pl. vii. fig. 4). In the present case I have only figured a few of these spines, not to complicate the figure too much. The spaces between the trabeculæ are filled in with a perforated cover. Aperture of zoœcial tubes about 0·06 mm. wide.

Loc. Victoria (*MacG.*); Port Stephens, 5–6 fath., New South Wales.

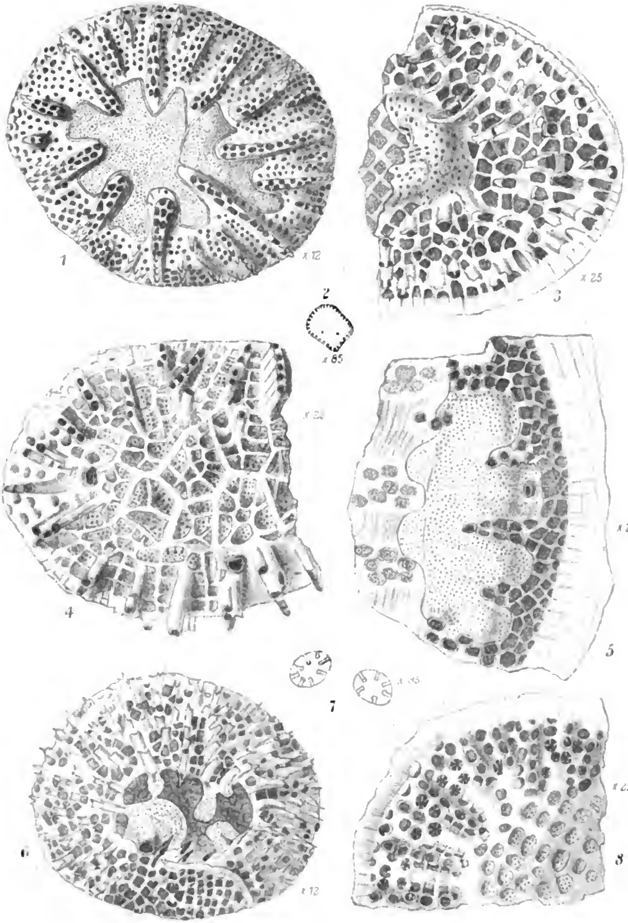
DISCOTUBIGERA? LINEATA, *MacG.* (Pl. XV. fig. 5.)

Diastopora lineata, *MacGillivray, Trans. Roy. Soc. Vict.* vol. xxi. p. 96, pl. iii. fig. 1.

Liripora lineata, *MacG. Cat. Mar. Polyzoa of Vict., Roy. Soc. Vict.* 1887, p. 32.

Discotubigera lineata, *Waters, Ann. Mag. Nat. Hist.* ser. 5, vol. xx. p. 260, pl. vi. fig. 24.

I have already (*loc. cit.*) alluded to the ovicell, but it has never been figured, and therefore I add a figure of an ovicell occurring near the border of the zoarium. It will be seen that it is of a type quite different from that of *Lichenopora*; but as yet we are in ignorance concerning the ovicells of *Discotubigera* and its allies.



A. W. Waters del. Michael lith. Mintern Bros. imp.

OVICELLS OF LICHENOPORÆ

Lichenopora Holdsworthii, *Busk*. (Pl. XV. figs. 7 & 8.)

Discoporella Holdsworthii, *Busk, Cat. Mar. Polyzoa*, pt. iii.p. 33, pl. xxx. fig. 4.

Lichenopora Holdsworthii, *Waters, Quart. Journ. Geol. Soc.* vol. xliii. p. 347; *Ann. Mag. Nat. Hist.* ser. 5, vol. xx. p. 261.

I have already (Quart. Journ. Geol. Soc. xliii. p. 347, and elsewhere) alluded to the "rays" in the zoœcial tubes and cancelli, and to Mr. Busk perhaps referring to these when he speaks of stellate pores

The ovicell occurs as a central inflation with large roundish depressions closed with a perforated pellicle. It spreads in between the radii in somewhat the same manner as in *L. californica* though not so marked on the surface. I have only seen the one ovicell; and if this was the only specimen of *L. Holdsworthii* known, I doubt if it would be possible without breaking up the specimen to decide whether there was an ovicell.

Loc. Living: Ceylon; Victoria; 'Challenger' station 142 (S. Africa). Fossil: Waipukurau (New Zealand).

EXPLANATION OF PLATE XV.

Fig. 1. *Lichenopora californica*, Busk. Showing ovicell extending between the radii. From Port Western (Victoria). × 12.

2. Cancellus of *L. echinata* showing denticles. × 85.
3. *Lichenopora echinata*, MacG. Shows to the left the lower surface of the ovicell formed by reticulated cells covered with a pellicle. The upper surface is pitted. × 25.
4. *Lichenopora victoriensis*. Shows ovicell and two ovicellular ducts. From Port Stephens, 5-6 fath. (New South Wales). × 25.
5. *Discotubigera lineata*, MacG. Shows the ovicell at the border of the colony, and also the ovicellular duct. From Port Jackson (New South Wales). × 25.
6. *Lichenopora echinata*. Shows the formation of the ovicell which starts from several points to meet over the centre. From Port Phillip. × 12.
7. Cancellus of *L. Holdsworthii*, showing rays. × 85.
8. *Lichenopora Holdsworthii*, B., with ovicell. From Port Phillip. × 25.

Researches into the Life-histories of *Glyciphagus domesticus* and *G. spinipes*.

By A. D. Michael, F.L.S., F.Z.S., F.R.M.S.

[Read 3rd May, 1888.]

(Plate XVI.)

For over three years last passed I have been, as opportunity offered, endeavouring to elucidate certain obscure points which I had observed in the post-embryonic development of the common

Glyciphagi, the specific names of which are mentioned in the title of this paper; it is the progress and results of those investigations which I now propose to record.

The inquiry has involved a considerable amount of care and labour, not only from the inherent difficulties of isolating, rearing, and watching these minute creatures, but also because it has necessitated very numerous dissections of soft hyaline *Acari*, some of them less than the fifth of a millimetre in total length, and of the cast skins of these organisms.

Glyciphagus is a genus of atracheate *Acari*, belonging to the family Tyroglyphidæ, but which is distinguished from the genus *Tyroglyphus*, or cheese-mites, by, *inter alia*, the rough cuticle, covered with granulations or vermiform markings, the pectinated or plumose hairs and long, slender tarsi of *Glyciphagi*, as *opposed* to the polished cuticle, setiform hairs, and usually shorter tarsi of *Tyroglyphi*, and more especially by the females of *Glyciphagus* possessing a central tubular projection from the posterior margin which is absent from those of *Tyroglyphus*: some years ago I showed this to be a bursa copulatrix, a fact which, I believe, is now generally admitted; the bursa doubtless exists in *Tyroglyphus*, as indeed Dr. Nalepa has proved in one species, but it does not form an exterior projection.

In order that this paper may be understood it is necessary to state, as shortly as possible, what a *Hypopus* is; but as, in a former paper read before this Society*, I entered fully into the question, I do not propose to detail the various opinions held by different authors on the subject, nor the investigations which led me to the results given, except so far as is absolutely requisite in order that this paper may be intelligible; I shall simply state conclusions, referring to that paper for all proofs and other information on the subject. *Hypopi* are minute *Acari* provided with a smooth, chitinous carapace, which conceals the whole, or almost the whole, of the creature; they are somewhat arched on the back, but still considerably compressed dorso-ventrally; the mouth-organs are rudimentary and the posterior pair of legs are terminated by hairs, not claws. *Hypopi* are most commonly found adhering to insects, miriapods, &c., and they have been ultimately shown to be a stage in the life-history of some *Acari* of the genus *Tyroglyphus* and one or two allied genera, although they are very unlike all other stages of *Tyroglyphi* in appearance. The stage does not occur in the life-history of every individual of a species, but in a comparatively limited number of instances. Mégnin considered that the stage occurred when, from drought or unfavourable circumstances, the colony was in danger of perishing, and that the nymphs of *Tyroglyphus* had the power of turning into *Hypopi* and so remaining until either the circumstances had again become favourable in the place where they were, or until they had emigrated into more suitable quarters—the *Hypopus* being better able to endure drought &c., and more capable of adhering to insects and thus escaping than the other stages of the creature. I think that I proved by the investigations detailed in the paper above referred to that this was an error, and that unfavourable circumstances did not affect the question—the Hypopial stage being a provision of nature to ensure the distribution of the species, occurring irrespective of adverse conditions, and that it occupied the period between two ecdyses in the life-history, commencing in the species which I was then studying at the second nymphal ecdysis.

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* "The *Hypopus* question," Journ. Linn. Soc., Zool. vol. xvii. (1884) pp. 371–394.

Glyciphagus is not one of the genera in which a Hypopial stage has ever hitherto been found to exist, except in the case of *G. Crameri* described by me in 1886 *; and this, as pointed out in the paper in which I described it, is an extreme species of the genus, which would hardly be included in the genus were it not for the connecting-links, and would undoubtedly fall within Haller's genus "*Dermacarus*" if that genus were retained. Of the two species named in the title, one, *G. spinipes*, was first recorded by Koch; and, so far as we know at present, there is not any difficulty in identifying it, and but little synonymy connected with it. *G. domesticus* can, however, hardly be said to be in this happy position: the synonymy of this species would probably be voluminous; but this is not the place to investigate it, beyond what is necessary for identifying the species that I have been experimenting upon. The species was originated by de Geer, who called it *Acarus domesticus*, the division of *Tyroglyphus* from *Glyciphagus* not having been effected at that time; one result of this has been that numerous writers have identified the creature with the common cheese-mite (*Tyroglyphus siro*, Linn.). Now, however, that the distinction between the two genera is understood, it is abundantly clear that de Geer's species was a *Glyciphagus*;

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* "Upon the Life-history of an *Acarus*, one stage whereof is known as *Labidophorus talpæ*. Kramer, &c.," Journ. R. Mic. Soc. 1886, pp. 377–390.

it appeared in 1778. In 1841 Gervais published a very short description and very imperfect drawing of a species which he called *Glyciphagus cursor*. In 1867 Robin and Fumose published a very carefully prepared article in Robin's 'Journal de l'Anatomie et de la Physiologie,' in which they, probably correctly, identified de Geer's and Gervais's species; but, for some reason which is not quite apparent, they retained Gervais's name, not de Geer's. M. Mégnin, in the observations mentioned below as having been made by him, has followed Robin and Fumose in calling the species *G. cursor*: unfortunately neither of these able authors gives a figure of their *G. cursor*; had Robin and Fumose added such a drawing as they furnish of *G. spinipes* no doubt could arise as to what their species is. A good figure of what is apparently the male of *G. domesticus* is given by Berlese (Acari Ital. fasc. xiv. no. 3); it is accompanied by a short description, which, however, is supplemented by the notes to the same work (fasc. i. pp. 9, 10). This author, however, does not say whether he considers it to be identical with *G. cursor*, and the points which he gives for identifying his species do not admit of comparison with those given by Robin and Fumose for *G. cursor*. I imagine the two species to be identical. Under these circumstances I have thought it best to give a figure of the female of the species I have been dealing with, to facilitate identification; it is, I think, the *G. domesticus* of de Geer and Berlese, and, so far as I can judge at present, it is also the *G. cursor* of the other authors above named.

It would be out of place here to give any formal description of such well-known creatures; but as these two species, *G. spinipes* and *G. domesticus*, are commonly found together, and are not easily distinguished at first, although a little practice enables the student to do so with facility and certainty, it may be useful to state some of the principal characters by which they may be distinguished; these are:—Firstly, that the tarsi of *G. spinipes* are thickly clothed with very fine short hairs (Pl. XVI. fig. 12), but do not bear any hairs much longer than the general average; the tarsi of *G. domesticus* are smooth, but have a few straight hairs or spines much longer than those of *G. spinipes* (fig. 5). The hairs on the tarsi of *G. spinipes* are best seen in dry specimens using an amplification of from 150 to 200 diameters; they are not so easily seen with lower powers nor in specimens mounted in balsam, or even in fluid. Secondly, the tarsi of *G. domesticus* are considerably longer than those of *G. spinipes*. Thirdly, *G. spinipes* has an obtusely conical shape anteriorly, and is suddenly contracted between the second and third pair of legs; *G. domesticus* has this form indicated but very slightly, being nearly as wide posteriorly as in the middle of the body; the difference can only be well seen in living specimens. Fourthly, the bursa copulatrix of the female projects considerably more in *G. domesticus* (fig. 7) than in *G. spinipes* (fig. 15). Fifthly, *G. domesticus* is a trifle the larger, but this cannot be relied upon. Sixthly, the hairs of *G. spinipes* are more deeply serrated and stronger than those of *G. domesticus*. Seventhly, the tibiæ of the first and second pairs of legs in *G. spinipes* each bear two large and thick curved, strongly-serrated hairs; these are much less developed in *G. domesticus*. Eighthly, the second joints of the third pair of legs in *G. spinipes* each bear on the outside a peculiar hair or scale (fig. 14), shaped like a husk of corn, and placed with the concavity inward; its outer surface is thickly clothed with fine hairs or processes: this structure is most developed in the female; it has not, I think, been mentioned by previous writers; it is not found in *G. domesticus*. Ninthly, *G. spinipes* when placed on its back, or otherwise disturbed, has a rapid struggling or fighting motion with its first and second pairs of legs, a little of which is seen in its ordinary walk; this style of movement is very characteristic of the species.

The Tyroglyphidæ, like most of the other *Acari*, have an inert period previous to each ecdysis; during this time the creature is motionless and apparently dead, except that it does not shrivel up; it is needless to say that a proper examination will disclose that the development of the creature in its next stage is progressing inside the dead cuticle.

GLYCIPHAGUS DOMESTICUS.

During the month of May, 1885, when I was examining some material which had been sent to me and which was swarming with *G. domesticus* in various stages, I observed that there were some which could only be classed as inert nymphs, but which had not quite the ordinary appearance of the creature in that stage; the cuticle was more opaque, and seemed thicker and whiter, the back was more arched, the empty skin of the legs was more apt to be rubbed off, as if the inert stage had lasted longer than usual, giving a case-like appearance; and I propose in this paper to use the expression "cases" to signify this phase in the life-history; it must, however, be understood that each case is only a nymphal skin, but it is a nymphal skin under special conditions. The finely granular marking or wrinkling of the cuticle of the species was very apparent, and when a portion was examined with a sufficient power this was resolved into the labyrinthine and vermiform wrinkling of which an illustration is given (Pl. XVI. fig. 3). It was also noticeable that the contents of each case were more drawn toward the anterior end than is usual in the nymph during ecdysis. Of course the first step was to ascertain that these cases were not simply dead creatures; for this purpose, in the latter part of May 1885 I isolated three in a separate glass cell, placing them under what experience had taught me would probably be favourable conditions of existence. On the 10th June, 1885, three immature *Glyciphagus domesticus* emerged from these cases. The cases did not split irregularly like an ordinary nymphal skin, but opened by the posterior end of the case, which had been concave, being pushed out so as to become rather convex, and separating from the lateral and ventral portions of the case, while it remained attached to the dorsal; thus when the creature within had escaped, the posterior end formed a sort of lid attached to the dorsal surface (fig. 4). This I subsequently found was the usual, although not the absolutely invariable, mode of opening. I did not then examine the precise stage that the creatures were in, but I noticed that the cases, although open, did not appear to be entirely empty (I subsequently found that what they contained was a cast skin).

On the 10th June, 1885, I placed thirteen more cases in a second cell, and submitted them, as I had hoped, to conditions similar to the first; but either from some defect in the arrangement of the cell, or from unfavourable weather, these specimens gradually died, so that toward the end of July there were not any alive. On the 30th July, 1885, I again isolated several cases in a separate cell. In a week I found that two of them were open at the posterior end and that there were two nymphs of *Glyciphagus domesticus* in the cell; more subsequently emerged from the other cases. I again observed that the cases from which they had come did not appear to be absolutely empty. I now took three of the nymphs which had emerged from the cases and placed them in a separate cell; in about a week they had all become inert; a few days later an adult female of *G. domesticus* escaped out of the cuticle of one of these inert nymphs, the others soon followed. The cast skin from which the adult emerged was thin and fine, very different in appearance from that of the cases. One point at least had now been established, viz. that the cases were a penultimate nymphal stage—*i. e.* that the nymph which emerged from the case became adult at its first ecdysis.

While these observations were in progress I also endeavoured to obtain a knowledge of the matter by dissecting the cases and their contents; but as, in order to avoid any chance of error, I have lately repeated these dissections on a large number of specimens, I will describe the results of both together in order to avoid repetition.

At this time I was forced by other engagements to abandon the investigation temporarily; and I did not make any further observations on the same species until the present year (1888). On January 25, 1888, I placed in a cell four cases taken from fresh material which I had obtained, but which contained very few cases, some of which I reserved for dissection; but in spite of my providing them with gentle warmth and slight moisture, such as would apparently form the most favourable conditions, these cases still (May 3) remain in the same condition as when placed in the cell*. On April 9, having found that a great many cases had now formed in the same material from which the last had been taken, I placed a number of these in three separate cells. On 21st April I found an inert nymph of *G. domesticus* in one of these cells which had escaped from a case, and must have emerged and become inert since the cell had been last examined, which happened to be two days; longer than usual. On the 26th April the adult emerged, and a second nymph had emerged and become inert prior to the final ecdysis. On the 1st May an adult female of *G. domesticus* emerged from this last-named nymph. I carefully examined it and made certain of the species.

Between the commencement of January and the end of April 1888, I dissected a large number of these cases of *G. domesticus*; the results were entirely confirmatory of those which I had obtained in 1885—viz., that inside each full case, and almost filling up the anterior portion of it, but not the legs, which were empty, was a protoplasmic mass which had a transparent, colourless, and almost structureless cuticle. This mass had a rounded

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* They subsequently emerged on 15th July.

posterior and a pointed anterior end; was compressed dorso-ventrally, particularly at the posterior margin; and had a more or less plain sulcation round it, as though dividing cephalothorax from abdomen (in some specimens this was very marked). The mass had the general form of a *Hypopus*, but there was not, in any instance, any trace of legs, mouth, or other external organs. In many instances the protoplasm appeared to be divided into large cells, like an egg in an early stage of segmentation; in others the cell-division appeared to have gone further, the cells being much smaller and finer, particularly in the posterior portion of the creature, but some of the larger cells remaining; in others, presumably more advanced, the finer granulation was more uniform. The mass was always motionless, but in one instance I did find a living nymph within the case instead of the inert mass; this of course was ready to emerge. The cases from which the occupant had emerged almost invariably contained the cast cuticle of the protoplasmic mass, which cuticle did not show a trace of legs, mouth, or any other organs.

GLYCIPHAGUS SPINIPES.

At the end of 1885 I was at a farm-house for a short time, and thought it a favourable opportunity to renew the investigation. I found in the chaff-house, in the dust and chaff, and also attached to the walls and beams, a number of cases which I at first supposed to be similar to those I had before dealt with: I soon, however, found that these were even more opaque than the former specimens, and that they were coarsely reticulated instead of being finely vermiform in markings; the empty cases also opened differently, the posterior cuticle breaking away from the dorsal and lateral, and remaining attached to the ventral, so that the posterior end opened downward instead of upward, and was more torn; the hinder part of the dorsal cuticle also was usually split along the median line and the two sides somewhat separated. It was therefore probable either that they were in a different stage from those observed in June and July of the same year, or that they were under different climatic or other conditions, or that they belonged to a different species of *Acarus*. I finally found that the last explanation was correct, and that these reticulated cases were those of *G. spinipes*. Between the 28th December, 1885, and the 1st January, 1886, I found a considerable number of these cases. I placed some of them in a cell as before and dissected others; these, in many instances, contained not the inert legless mass found in the cases of *G. domesticus*, but a distinctly formed living *Hypopus*, which had not assumed the usual brown chitinous colour, and could not be called active, but still was fully formed, and provided with short and stumpy, but thoroughly-developed legs, which it could move about, although only in a feeble manner; it was not capable of walking (ordinary *Hypopi* are very active), and it was evidently not in a condition fitted for existence as a free-living creature; but yet it was undoubtedly alive and fully formed; its total length was about ·19 millim., its greatest width about ·15 millim. Each tarsus of the first three pairs had an exceedingly long, very slightly curved, blunt claw; the tarsi of the fourth pair were devoid of claws and hairs. A figure of this *Hypopus*, carefully drawn from a specimen dissected out of a case in January 1888, is given in Pl. XVI. fig. 9. The majority of the *Hypopi* dissected out of the cases were not capable of any movement; it was only a few which were able to move their legs. I now searched the chaff and material, and the dust &c. swept from the walls and beams of the chaff-house, very carefully in hopes of finding active *Hypopi* which had emerged and were capable of walking about, but neither on this nor on any other occasion have I been able to discover anything of the kind; but I did find one or two inactive *Hypopi* not capable of any movement, which seemed as if, from some accident, the cases had been broken away from them. On 2nd January, 1886, I took one of these, and one of the *Hypopi* dissected out of a case and which could move its legs, and put them in a cell by themselves. I watched them at frequent intervals, but they did not die or shrivel up. On the 15th January I missed one of the *Hypopi*; but close to where it ought to have been I saw a nymph of *Glyciphagus spinipes*, which had evidently just emerged and had some thin membrane attached to it; on detaching this membrane, and examining it with a higher power, I found that it was the cast skin of the *Hypopus*. I put both the nymph and the cast skin in glycerine for permanent preservation. A few days later I dissected four more of the cases and took out four *Hypopi* and placed them on a small piece of dried leaf in a separate cell; the next day I found that two had collapsed, probably having been injured during the dissection of their cases. The following day I observed that one of the remaining two had moved, and on touching it with a fine hair I saw that it was alive and able to move about very slowly; but the day after it had collapsed and was dead. There was now only one *Hypopus* left; this did not move nor show any sign of life; but, on the other hand, it did not collapse, and in this condition it remained for nearly four months. I watched it every day without seeing any change until the 24th May, 1886, on which day a healthy nymph of *G. spinipes* emerged from the Hypopial skin.

While this experiment was progressing I had also watched the cell in which I had placed the cases: one nymph of *G. spinipes* had appeared in the cell and one case was open at the posterior end; otherwise there was not any change. But on the 26th May I found two more cases open and two *Hypopi* had apparently crawled out of them; on touching these *Hypopi* they appeared inert and incapable of motion, but a few days after nymphs of *G. spinipes* emerged from them.

In October 1887 I again obtained more material from the same chaff-house, and also from another farm some fifty miles distant from the first; this latter contained *G. domesticus*. In both samples the *Glyciphagi* were numerous and the larvæ and nymphs were abundant, but I could not find any cases or any trace of *Hypopi* in either.

In January 1888 I once more took up the investigation: I obtained material and sweepings from the same chaff-house and again found the reticulated cases of *G. spinipes*; most of them were open at the posterior end, the occupants having emerged. I put seven of the full cases in a separate cell; in one of these cases I could easily distinguish a *Hypopus* moving its legs. I also found one which had apparently come out of the case, and which was capable of the same amount of motion; it was from this specimen that fig. 9 was drawn. On February 6 I found that one of the seven cases was open and that a nymph had emerged from it. I isolated this in another cell, which I will call cell 5. On February 8 another nymph emerged from a second of the seven cases. I placed this nymph also in cell 5. On February 9 an adult *G. spinipes* emerged from one of the nymphs in cell 5, the second nymph also was inert. On February 26 an adult of the same species emerged from the remaining inert nymph.

From this time up to the end of April, when I closed the observations, nymphs of *G. spinipes* continued to emerge at intervals from the remainder of the seven cases, and from other cases which I had put in different cells, and adults continued to emerge from the nymphs, so that there could not be any doubt of the species, or of the process being a regular one.

I also in January 1888, and again in April of the same year, dissected numerous reticulated cases from which the nymph had emerged; in almost every instance I found within the case an unmistakable cast Hypopial skin having perfectly distinct legs.

Concurrent investigations by M. Mégnin.

It appears that while I was engaged on these observations M. Mégnin was also investigating some points relative to the *Glyciphagi*, and, *inter alia*, almost the same subject as my own *. We did not either of us know of the other being so occupied. Mégnin approached the matter from a standpoint different from mine: he did not find an object which excited his curiosity to discover its cause; but it struck him that as *Tyroglyphus* has a Hypopial stage, so closely allied a genus as *Glyciphagus* ought also to have it, and he deliberately set himself to search for that stage; but he tells us that he searched in vain; he tells us, however, that he discovered an equally curious phenomenon, which he says shows how prodigal nature is in processes for preserving the lower creatures. He, believing that the change of a nymph of *Tyroglyphus* into a *Hypopus* is caused by unfavourable surroundings, states that under similar conditions he found that those of *Glyciphagus* became inert, that a liquefication of all the organs took place "as in a change of skin," and that the gelatinous substance collects in the cavity of the "thorax" in the form of a spherical mass surrounded by a chitinous envelope and thus forming a cyst very similar to those formed by some Infusoria previous to the drying up of the water in which they are contained. Mégnin suggests that in this condition the dried nymphal skins containing the cysts would be blown about by the wind and would thus finally arrive at some place where the conditions would be favourable and would then emerge, and that the species would be thus distributed.

Mégnin says that his species were *G. spinipes* and *G. cursor*, which latter is, as before stated, presumably the same as *G. domesticus*; but he does not distinguish between the life-histories of the two, nor identify any particular observations with either species.

I do not intend here to discuss the vexed question of whether the liquefication of the organs of an *Acarus* during ecdysis is complete, involving a return of all the organs to an egg-like state, or whether it is only partial: the former has long been Mégnin's view, and he cites Claparède as confirming it; but on reference to the Swiss author's writings this does not seem to be by any means certain. Dr. Nalepa, who has lately investigated the subject with regard to the Tyroglyphidæ, is strongly of opinion that it is only partial*. I was formerly inclined to think, chiefly on Mégnin's authority, that it was complete; but more lately, having paid some personal attention to the subject, I have come to a conclusion with regard to the Oribatidæ † more in accordance with Dr. Nalepa's views. It is clear that Mégnin has been observing a process either identical with or very similar to what I have seen in *G. domesticus*, but that not having found the more fully developed *Hypopus* in *G. spinipes* he has naturally not recognized that what he found was really a rudimentary *Hypopus*—the difference of the spherical form of the inert mass found by him in his cysts from the more *Hypopus*-like form of the corresponding mass found by me in *G. domesticus* may possibly be accounted for by his specimens having been examined more shortly after the change commenced than mine were, or by his observations having been made on *G. cursor*, and that species not being really identical with *G. domesticus*, although much resembling it, but having the Hypopial stage even more rudimentary.

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* Comptes Rendus, ciii. (1886) pp. 1276–8.

It is quite possible that Mégnin's idea that the inert nymph when containing the Hypopial form, or, as he calls it, the cyst, would be blown about by the wind may be correct: I do not see that it would be more liable to be so blown about during this than during any other ecdysis, except in so far as this may last longer; but undoubtedly the creature within, protected by its Hypopial skin, would bear more exposure and rough treatment than the *Acari* would during other ecdyses. It will probably, however, be gathered from the foregoing pages that I cannot agree with Mégnin that the change to the Hypopial, or as he calls it encysted, condition is produced by desiccation or unfavourable surroundings. I have not conducted a series of experiments expressly designed to determine this exact point, as I did with the *Tyroglyphi*; but my material was not kept in any desiccated or unfavourable condition; on the contrary it was naturally kept under the most favourable conditions I could devise, and the *Glyciphagi* throve admirably; but the cases containing Mégnin's cysts were formed rapidly and numerously in it; from which, and from the general experience acquired during the somewhat lengthy observations above described, I feel assured that with the *Glyciphagi*, where the Hypopial stage is more or less rudimentary, as with the *Tyroglyphi*, where it is an active and functional one, the change to this stage is normal, although not existing in the life-history of every individual, and is not induced by desiccation or other unfavourable conditions; but, on the contrary, proceeds best and most rapidly when all conditions are favourable. I do not deny that a creature may remain longer in the Hypopial condition after it has been formed when the surroundings are more suitable to that stage than to the ordinary nymphal state, than it will when the converse is the case; I think this not improbable, although I have not seen any evidence to prove that such is the fact.

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* "Die Anatomie der Tyroglyphen," Sitzungsb. k. Akad. Wien, i. Abth. Juli-Heft, 1885, p. 151.

† "British Oribatidæ," Ray Society, vol. ii. (London, 1888), p. 604.

CONCLUSIONS.

The results of the investigations detailed above may be summarized as follows:—

1. There is a Hypopial stage in the life-history of *Glyciphagus* just as there is in that of *Tyroglyphus*.

2. That this Hypopial stage is far less developed in *Glyciphagus* than in *Tyroglyphus*, and is not, so far as is known at present, an active stage.

3. That we do not at present know whether it occurs in all species, but it certainly does not occur in the life of every individual of a species.

4. That the stage is not the result of desiccation or other unfavourable circumstances, but occurs as often under favourable conditions.

5. That the stage, in the species investigated, occupies the period between the penultimate ecdysis and that immediately previous.

6. That in *G. spinipes* the *Hypopus* is fully formed and capable of moving its legs, but not of walking or other active movement; that it never becomes hard, or of the dark colour of the ordinary chitin of active *Hypopi*. That, as a rule, it does not even leave the skin of the young nymph in which it is formed; but that the more adult nymph is formed within the *Hypopus*, and emerges

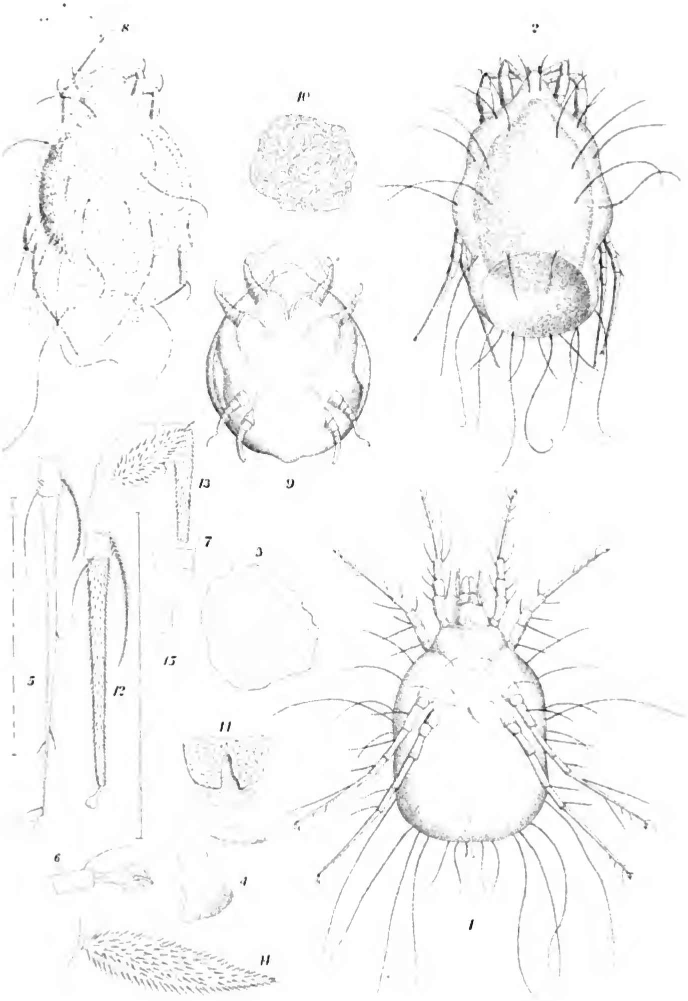
from it, while the *Hypopus* is still within the young nymphal skin; so that the *Hypopus* is not ever seen, except that, in a few instances, it may crawl just outside the young nymphal skin when the more advanced nymph is likely soon to emerge.

7. That in *G. domesticus* the Hypopial stage is even more rudimentary; what represents the *Hypopus* retaining only the general form of that creature, but being without legs or other external organs, and that it never emerges from the young nymphal skin.

8. That in both species the young nymphal skin within which the *Hypopus* is developed thickens and forms a "case" different in appearance from the skin during ordinary ecdysis.

EXPLANATION OF PLATE XVI.

Fig. 1. *Glyciphagus domesticus*: adult female, underside; × 95.
2. Ditto: "case" containing the inert mass (very rudimentary Hypopial condition); × 150.
3. Ditto: a portion of the cuticle of the "case," to show the vermiform markings; × 200.
4. Ditto: posterior end of "case" from which the nymph in its last stage has emerged; side view, to show the mode of opening.
5. Ditto: fourth left tarsus of adult female from above; × 200. At the side is a line showing the extreme width of the abdomen; same amplification.
6. Ditto: claw and caruncle from below, drawn from the living foot when pressed by the creature against glass; × 500.
7. Ditto: bursa copulatrix; × 200.
8. *Glyciphagus spinipes*: "case" containing the *Hypopus*; × 150.
9. Ditto: *Hypopus* dissected out of the "case"; × 180.
10. Ditto: a portion of the cuticle of the "case," to show the reticulated markings; × 200.
11. Ditto: posterior end of "case" from which the nymph in its last stage has emerged; seen from above, to show the mode of opening.
12. Ditto: fourth left tarsus of adult female from above; × 200. At the side is a line showing the extreme width of the abdomen; same amplification.
13. Ditto: part of the third left leg of adult female from the outer side; × 250.
14. Ditto: hair from the second joint of the same leg; × 500.
15. Ditto: bursa copulatrix.



[illegible] GLYCIPHAGUS DOMESTICUS AND [illegible]

[illegible]

Studies of the Macrochires, Morphological and otherwise, with the view of indicating their Relationships and defining their several Positions in the System. By R. W. SHUFELDT, M.D., C.M.Z.S., Captain, Medical Corps, U.S. Army. (Communicated by W. K. PARKER, F.R.S., F.L.S.)

[Read 19th January, 1888.]

(PLATES XVII.-XXIV.)

IT may be remembered by those who are interested in the structure and classification of birds that I published, in the 'Proceedings' of the Zoological Society for 1885 (pp. 886-915), a memoir entitled "A Contribution to the Comparative Osteology of the *Trochilidæ*, *Caprimulgidæ*, and *Cypselidæ*." That memoir professed to be but little more than a mere introduction to a subject which I will here enter upon more fully, although the opinions there set forth are, in the main, substantially those that I still hold, at least in the case of the *Trochilidæ* and *Caprimulgidæ*. Since the date of that paper, however, I have never ceased in my endeavour to gather together the necessary material for this, my second contribution on the subject; and, as will be seen by the list of specimens in the subjoined Table, these efforts have met with a very fair measure of success.

In the conclusions at the close of my former paper I contended that all the existing Caprimulgine birds of the world's avifauna should be grouped in one order, the CAPRIMULGI. In this group, no doubt, would fall *Nyctibius* and *Steatornis*, and very probably *Podargus* and *Psalurus*. Further, I proposed that the Humming-birds should constitute another order, to be known as the TROCHILI. I made no final determinations in regard to the Swifts, beyond that they should be separated from the Trochili; but these birds will be carefully studied in the present memoir, and my opinions in regard to them stated in the conclusions which close it.

Finally, I had something to say about certain apparent resemblances between the bones in the roof of the mouth of a Trogon and the corresponding structures in a Humming-bird. But my remarks were only drawn from a paper by W. A. Forbes published in the 'Proceedings' of the Zoological Society three or four years previous to my quoting them*, and at the time I had not had an opportunity of personally examining the skeleton of a Trogon. In the present paper, however, the case will, in this respect, be different; for, thanks to the kindness of Dr. P. L. Sclater, I have been enabled to study in this connection the skeletons of two different species of Trogon, which he has obligingly lent me for the purpose. For other material I am under obligations to a number of friends, to whom I here desire to express my sincere thanks; and I believe it will be found that in the proper column of the Table below I make due acknowledgments, by entering the names of the several donors opposite the specimens they have been so good as to send me. Indeed, had it not been for their kind and ready assistance, it would have been impossible for me to have completed the present work. Such material as I have been enabled to collect myself is also set forth in the Table in question. My thanks are further due to the Editors of 'The Auk' and of 'Forest and Stream,' for kindly inserting for me requests for specimens of birds in alcohol to be used in the present connection.

Glancing over this list of material, it will be observed that, so far as the ordinary forms of the American Caprimulgine birds are concerned, it admits of giving a full account of their structure. The skeleton in these also may be conveniently compared with the skeleton in the two species of Trogons likewise represented; and these latter with other types presented in the Table, as well as with such a skeleton as is presented in *Geococcyx californianus*, which I have elsewhere studied (Journ. Anat. and Phys. Lond. vol. xx. 1886, pp. 244–266) and published an account of its characters.

Similarly, we find the North-American CYPSELI very well represented, the only important form not found among my material being *Cypseloides niger*, and all my efforts to secure specimens in alcohol of this interesting Swift have utterly failed†. In my first contribution to the anatomy of these birds (P. Z. S. 1885, p. 886), I advanced the opinion that they were but profoundly modified Swallows, and should not be grouped with the Trochili in our classification of birds. We now have the opportunity of ascertaining how this opinion will stand the test of more extensive researches into their structure, with the aid of a far better supply of material than I was enabled to handle upon the first occasion.

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* Forbes, W. A., "Note on the Structure of the Palate in the Trogons (*Trogonidæ*)," P. Z. S. 1881, p. 836.

† I have since received alcoholic specimens of this form from my friend Prof. A. Newton, F.R.S., who kindly procured them from Jamaica for me.

The Table also presents a very fine collection of skeletons and specimens in alcohol of the Trochili; and the structure of these, as I say, will in the following pages be thoroughly compared with the corresponding structures to be found in the Swifts.

It is further my intention to compare the Swifts thoroughly with the Swallows; and to this end I find that I have examples of every genus of the latter birds, as they are represented in the North-American or, rather, United States avifauna. Up to the present time my efforts to secure specimens in alcohol of such a form as *Hemiprogne zonaris* have not succeeded; but Mr. C. B. Cory has kindly written for me to some collectors in the West Indies, and I have taken the liberty to apply for some of these birds to the governmental authorities in Jamaica. Sufficient time has scarcely elapsed for me to have received replies, but I am under the impression that when this type comes to be compared with more typical Swifts, some light will be thrown upon the present subject.

Finally, it is my intention in this memoir to review some of the structural and other characteristics of the *Passeres*; not that the majority of the ordinary ones are not already known to us, but rather to have them arranged systematically at hand, for comparison in the present connection. I have chosen for this purpose a specimen of *Ampelis garrulus*, being influenced in my choice more particularly by the fact that, although it happens to be Passerine, it is not strictly and typically so: moreover, some ornithologists apparently recognize in it certain Swallow-like characters, more especially those which have a certain resemblance to such a bird as *Progne subis*, which it appears to approach in the form of the bill. Others, and much earlier authorities, have entertained the notion that the Waxwings belong rather to the *Clamatores*, being probably related to the *Tyrannidæ*, and should be placed near them. So that, on the whole, I trust that, in addition to meeting other ends in view, a glance at the structure of this strictly American representative of the *Ampelinæ* will not come amiss.

The order in which I propose to present the material to be examined will be:—first, a sketch of the morphology of

Table, showing the Material examined in this Memoir, and the Sources from whence it was obtained, and its Character.

Specimens, Age and Sex.	No. of specimens examined.	Collector's Name.	Donor's Name.	Locality and Date.	Remarks.
Trogon mexicanus	1	Unknown	P. L. Sclater	V. de Fuego, Guatemala.	Complete skeleton.
T. puella	1	Unknown	P. L. Sclater	V. de Fuego, Guatemala.	Complete skeleton.
Antrostomus vociferus, ad., ♂	1	Unknown	Jno. H. Sage	Portland, Ct.; Aug. 12th, 1886.	In alcohol.
Phalænoptilus Nuttalli, ad., ♂	1	R. W. Shufeldt	....	Fort Wingate, New Mexico; July 12th, 1885.	Complete skeleton.
P. Nuttalli, ♂	1	R. W. Shufeldt	....	Fort Wingate; July 12th, 1885.	Incomplete skeleton.
Chordeiles virginianus	1	Purchased	....	Near Chicago, Ill.; July 1886.	Adult: in alcohol.
C. virginianus, var. *Henryi*	3	R. W. Shufeldt	....	Fort Wingate, N. Mexico; June 1886.	Adults: in alcohol.
C. virginianus, var. *Henryi*	1	R. W. Shufeldt	....	Fort Wingate; July 1886.	Adult: skeleton.
C. texensis	1	R. W. Shufeldt	....	Fort Wingate; June 1886.	Adult: in alcohol.
C. texensis	1	R. W. Shufeldt	....	Fort Wingate; June 1886.	Adult: skeleton.
Chætura pelagica, adults	2	G. S. Miller, Jun.	G. S. Miller, Jun.	Peterboro', N.Y.; July 19th, 1886.	Complete skeletons.
C. pelagica	2	Luther N. Rossiter	Luther N. Rossiter	Lake Forest, Illinois; July 10th, 1886.	Adults, ♂ and ♀, in alcohol, a mated pair, taken with a net.
C. pelagica, adults	4	G. S. Miller, Jun.	G. S. Miller, Jun.	Peterboro', N.Y.; July 19th, 1886.	In alcohol.
C. pelagica, adults, ♂ & ♀	4	A. K. Fisher	A. K. Fisher	Sing Sing, N.Y.; June and July 1886.	In alcohol.

Micropus melanoleucus, adult, ♂.	1	R. W. Shufeldt	....	Fort Wingate, N. Mexico; April 23rd, 1885.	Complete skeleton.
M. melanoleucus, adult.........	1	R. W. Shufeldt	....	Fort Wingate; Sept. 1885.	In alcohol.
M. melanoleucus, adult.........	1	R. W. Shufeldt	....	Fort Wingate; June 1886.	In alcohol.
M. melanoleucus, adults	5	R. W. Shufeldt	....	Fort Wingate; Sept. 8th, 1886.	In alcohol.
M. melanoleucus, adults	10	R. W. Shufeldt	....	Fort Wingate; Sept. 11th, 1886.	Nine in alcohol, and one trunk taken from a skin.
Cœligena clemenciæ, adult, ♂	1	F. Stephens	F. Stephens	S. C. Mts., Arizona Terr.; May 14th, 1884.	Sternum and shoulder-girdle.
Trochilus colubris, adult, ♀...	1	H. K. Coale	H. K. Coale	Tollestone, Ind.; Aug. 5th, 1884.	In alcohol.
T. colubris, adults, ♂ & ♀ ...	2	G. S. Miller, Jun. ...	G. S. Miller, Jun. ...	Peterboro', N.Y.; May 21st, 1886.	In alcohol.
T. colubris, adults, ♂ & ♀ ...	2	G. S. Miller, Jun. ...	G. S. Miller, Jun. ...	Peterboro', N.Y.; May 23rd & 25th, 1886.	Skeletons.
T. colubris, adults, ♂ & ♀ ...	2	Jno. H. Sage	Jno. H. Sage	Portland, Ct.; July 12th & 13th, 1886.	In alcohol.
T. colubris, juv., ♂	1	Jno. H. Sage	Jno. H. Sage	Portland, Ct.; July 23rd, 1886.	In alcohol.
T. Alexandri, adult, ♂	1	R. W. Shufeldt	....	Fort Wingate, N. Mexico; April 23rd, 1885.	Skeleton.
T. Anna, adults, ♀	2	W. O. Emerson	W. O. Emerson	Haywards, Cal.; May and June 1886.	In alcohol.
T. Anna, juv. ♂, ad. ♂	2	F. Stephens	F. Stephens	San Barnardino, Cal.; Sept. 27th, 1884.	Sterna and shoulder-girdles.
T. platycercus, adult, ♂	1	F. Stephens	F. Stephens	San Bernardino, Cal.; July 28th, 1884.	Sternum and shoulder-girdle.
T. platycercus, adults, ♂ & ♀	2	R. W. Shufeldt	....	Fort Wingate, N. Mexico; June 12th, 1886.	In alcohol.
T. platycercus, adult, ♂	1	R. W. Shufeldt	....	Fort Wingate; Aug. 13th, 1886.	In alcohol.

Table (*continued*).

Specimens. Age and Sex.	No. of specimens examined.	Collector's Name.	Donor's Name.	Locality and Date.	Remarks.
Trochilus rufus, adults, ♂ & ♀.	12	R. W. Shufeldt	....	Fort Wingate, N. Mexico; August 1886.	In alcohol.
T. rufus, adults & juv., ♂ & ♀	13	R. W. Shufeldt	....	Fort Wingate; August 1886.	Skeletons.
T. Calliope, adults, ♂ & ♀ ...	2	F. Stephens............	F. Stephens	San Bernardino, California.	Sterna and shoulder-girdles.
T. Calliope, juv.	2	F. Stephens............	F. Stephens	San Bernardino, Cal.; May 24th, 1885.	In alcohol: nestlings.
T. Calliope, ♂, ♀, & juv. ...	12	R. W. Shufeldt	....	Fort Wingate, N. Mexico; Aug. 1886.	In alcohol.
T. Calliope, adults, ♂	3	R. W. Shufeldt	....	Fort Wingate; Aug. 1st, 1886.	Skeletons.
Iache latirostris, adult, ♀ ...	1	F. Stephens...........	F. Stephens	S. K. Mts., Arizona Terr.; June 12th, 1884.	Sternum and shoulder-girdle.
Progne subis, adult, ♀	1	R. W. Shufeldt	....	Fort Wingate, N. Mexico; June 15th, 1886.	Skeleton.
P. subis, adult, ♀	1	A. K. Fisher	A. K. Fisher	Sing Sing, N.Y.; June 29th, 1886.	In alcohol.
P. subis, adults, 1 ♂ & 2 ♀...	3	R. W. Shufeldt	....	Fort Wingate, N. Mexico; June 1886.	In alcohol.
Petrochelidon lunifrons, juv...	1	R. W. Shufeldt	....	Fort Fetterman, Wyo.; June 1886.	Incomplete skeleton.
P. lunifrons, adults, ♂	2	R. W. Shufeldt	....	Fort Wingate, N. Mexico; July 16th, 1886.	Complete skeletons.
P. lunifrons, adults	2	R. W. Shufeldt	....	Fort Wingate; June 1886.	In alcohol.

Chelidon erythrogaster, adult, ♂.	1	R. W. Shufeldt	R. W. Shufeldt	Fort Wingate; July 16th, 1886.	Complete skeleton.
C. erythrogaster, juv., ♂	1	R. W. Shufeldt	....	Fort Wingate; June 1885.	In alcohol.
C. erythrogaster, adults, ♂	2	R. W. Shufeldt	....	Fort Wingate; June 1886.	In alcohol.
C. erythrogaster, juv., ♀	1	R. W. Shufeldt	....	Fort Wingate; Sept. 11th, 1886.	In alcohol.
C. erythrogaster	1	H. K. Coale	H. K. Coale	Chicago, Ill.; Aug. 20th, 1886.	In alcohol.
Tachycineta bicolor, adult	1	G. S. Miller, Jun.	G. S. Miller, Jun.	Peterboro', N.Y.; April 26th, 1886.	In alcohol.
T. thalassina, adults	3	R. W. Shufeldt	....	Fort Wingate, N. Mexico; July 1885.	Skeletons.
T. thalassina, adults	3	R. W. Shufeldt	....	Fort Wingate; June 1886.	In alcohol.
Clivicola riparia, adults	4	E. M. Hasbrouck	E. M. Hasbrouck	Port Byron, N.Y.; Aug. 7th, 1886.	Two in alcohol; two skeletons.
C. riparia, 1 adult and 4 nestlings.	5	Luther N. Rossiter	Luther N. Rossiter	Lake Forest, Ill.; July 10th, 1886.	In alcohol.
C. riparia, adults	3	H. W. Henshaw	H. W. Henshaw	Washington, D.C.; July 10th, 1886.	In alcohol.
C. riparia, adults	2	J. G. Parker	J. G. Parker	Chicago, Ill.; Aug. 19th, 1886.	In alcohol.
Stelgidopteryx serripennis, adult.	1	G. S. Miller, Jun.	G. S. Miller, Jun.	Peterboro', N.Y.; May 7th, 1886.	In alcohol.
S. serripennis, adult	1	H. W. Henshaw	H. W. Henshaw	Washington, D.C.; July 10th, 1886.	In alcohol.
Ampelis garrulus, adult, ♀	1	R. W. Shufeldt	....	Fort Fetterman, Wyo.; 1879.	Incomplete skeleton.
A. cedrorum, adult, ♂	1	H. K. Coale	H. K. Coale	Chicago, Ill.; Aug. 20th, 1886.	In alcohol.

Ampelis cedrorum; secondly, a study of the osteology of *Trogon mexicanus* and *T. puella*; thirdly, an examination of the structure of a number of the CAPRIMULGI; fourthly, an investigation of the anatomy of the North-American *Hirundinidæ*; fifthly, similar inquiries into the morphology of certain CYPSELI and TROCHILI, including extensive comparisons with the facts brought out in the first sections of the paper; and, lastly, a section devoted to my final Comparisons and Conclusions.

THE MORPHOLOGY OF AMPELIS CEDRORUM.

From an external examination of the subject, we find that the following characters are presented:—

1. The soft feathers on the top of the head unite to form a conspicuous crest.

2. The bill is broad at its base, rather short, and vertically compressed; while both mandibles show a distinct notch at the sides near the apices.

3. The cleft of the gape extends nearly as far back as the anterior arc of the eyelids.

4. The nostrils are subelliptical and scaled.

5. The wings are ample, pointed by the 3rd primary of the 10 composing one of them, the 1st primary being rudimentary.

6. Peculiar wax-like prolongations of the shaft are found in certain of the wing-feathers, and in some individuals in the tail-feathers.

7. Tail very slightly rounded, and composed of 12 rectrices.

8. Lateral plates of tarsus subdivided, with the anterior portion of this envelope composed of six distinct scutes.

9. Feet moderately strong, and characterized by having the basal phalanges of middle and outer toes more or less united.

10. In form, the body is somewhat robust and full-chested.

To this we may add that the Cedar-bird builds its nest upon trees, and lays spotted eggs, and that the young have a different coloration of plumage from their parents, which, in this respect, are alike.

On plucking the specimen the following additional characters are revealed:—

11. The pterylosis agrees almost exactly in pattern with the pteryloses of the majority of Passerine birds. *A. cedrorum* has, however, a lateral and narrow tract running longitudinally down

each side of the neck; these connect the humeral tracts with the feathering of the head.

Otherwise both the dorsal and ventral tracts of the Cedar-bird agree very well with the details of this important character as seen in such a Passerine form, *e. g.*, as *Motacilla alba.* This fact may be better appreciated by comparing my drawings of the former (Pl. XVII. fig. 1 *a* & *b*) with Nitzsch's figures of the pterylosis of the latter *.

12. The oil-gland is found to be nude, and this gland has a form such as is assumed among the great majority of the *Passeres.*

Upon removing the integument, one of the most convenient anatomical points to be first examined is the method of insertion of the muscles of the patagium. In the case of a small bird such as we have in *Ampelis*, our present subject, I find an easy way to do this is to seize the elbow of the plucked pectoral limb with the thumb and index finger of the left hand, in such a manner that the palmar surface of the index finger is applied to the under surface of the patagium, and keeps it on the stretch. The thumb is opposed to this, and firmly holds the elbow-joint, and no more. We now make an incision, with the scalpel in our right hand, through the skin, down the line of the triceps muscle, and another at right angles to it, along the line of the ulna: then carefully dissecting back the triangular flap of integument thus outlined, the parts to be examined come nicely into view.

13. In *Ampelis* the insertion of the *tensor patagii longus* and *brevis* are typically Passerine in character, as may be seen in the drawing here presented of these parts, which I made directly from my dissection (Pl. XVII. fig. 2), and from Prof. Garrod's excellent description, in his memoir upon the anatomy of the group†, of this method of insertion, as we find it in nearly all Passeres.

In *A. cedrorum*, however, we find another patagial muscle present in all Passeres which I have examined, which elsewhere I have named the *dermo-tensor patagii*, marking it *dt.p.* in

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* Nitzsch's 'Pterylography:' translated from the German by W. S. Dallas, and edited by P. L. Sclater, for the Ray Society. London, 1867: Taf. iii. figs. 1 & 2.

† Garrod, A. H., "On some Anatomical Characters which bear upon the Major Divisions of the Passerine Birds," P. Z. S. 1876, pp. 506-519 (read June 6th, 1876).

Pl. XVII. fig. 2 of the present memoir. This muscle arises from the inner surface of the skin at the lower part of the neck, its fibres converging as they pass towards the shoulder to terminate in a small and delicate tendon, which accompanies the tendon of the *tensor patagii longus* in the free marginal fold of the patagium, and merges with it about halfway between the humerus and carpus. When I come to discuss this muscle in the *Hirundinidæ* I will enter more fully upon it, its relations, and the birds wherein I have thus far detected its presence.

14. The musculature of the lower larynx of *Ampelis cedrorum* is of a very perfect Acromyodian type; I distinctly make out *five* pairs of intrinsic muscles inserted, as usual in Passeres, into the ends of the three upper bronchial semi-rings; and, in addition to these, there is a well-developed pair of sterno-tracheales.

These lower laryngeal muscles are here not only firm and fleshy, but easily individualized—a feat best accomplished with a pair of dissecting-needles, under the 2-inch objective of a good microscope.

Both in structure and position, then, the syrinx of *Ampelis* is of a typical Passerine type.

15. Turning next to the *pectoral muscles*, I find all three—the *pectoralis major*, the *p. secundus*, and *p. tertius*—to be present and fully developed. They also have their usual origins and insertions.

16. In examining the muscles of the thigh, with their vessels and nerves, I find that the ambiens and accessory femoro-caudal are both absent, while the femoro-caudal, the semimembranosus, the semitendinosus, and accessory semitendinosus are all present. The main artery is the sciatic; the main nerve the sciatic nerve; and the main vein the femoral.

In all of these particulars *Ampelis cedrorum* agrees with the highest types of Passerine birds.

17. At the lower third and at the back of the tarso-metatarsus I find in both feet that the tendons of the *flexor longus hallucis* and the *flexor profundus digitorum* are not connected by a fibrous vinculum. This is also another Passerine character.

18. In examining the heart and great vessels, I find but one carotid artery—the left one—passing up in front of the vertebræ in the neck.

19. I find the nostrils in *Ampelis* but very feebly partitioned from each other by a median membro-cartilaginous septum.

20. The alimentary canal agrees in general with the Passerine birds, and a small pair of *cæca coli* are present.

The Skeleton of Ampelis.

To any one who has examined series of skeletons of Passerine birds, it is a well-known fact that, as we pass from one specific form to another, from the higher to the lower types of organization, or *vice versâ*, we are impressed with the very few and inconspicuous structural modifications that we encounter; as we serially investigate the allied species of a group or groups, the shading of nearly all of the morphological characters of one species into those of another, and of the latter into the next nearest related form, is, as a rule, extremely gradual, and almost beyond the power of the pen to adequately describe. Yet, if we choose birds from the extremes of the Passerine order, very excellent taxonomic characters are met with, and if closely studied often point to affinities otherwise obscure or very puzzling.

As shown in many of the characters of its skeleton, *Ampelis cedrorum* seems to hold a sort of middle position here; and I think we shall find that, in some particulars, it is not to be distinguished from the highest types of the Oscines, while in others it possesses marked affinities with the Clamatorial plan of skeletal structure.

21. *Of the Skull* (Pl. XVII. figs. 4 & 6).—We find the superior osseous mandible of *Ampelis* to be somewhat flattened or compressed from above downwards; the narial apertures are large and subelliptical in outline. This part of the skull is broad at its base, tapering rather gradually to its apex; while above, its naso-frontal regions gradually merge into each other, there being no well-defined transverse line dividing them. The median rhinal partition, or nasal septum, is wholly in cartilage in this bird (Pl. XVII. fig. 4)—a character wherein it agrees with such forms as *Hesperocichla* (Pl. XVII. fig. 5), *Merula*, and probably all the higher Thrushes, as well as with such a type as *Otocoris**. On the other hand, a very well-developed nasal septum is to be found in the skulls of the American *Tyrannidæ*, as, for example, in such a Flycatcher as *Tyrannus verticalis* (Pl. XVII. fig. 3). So

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* Shufeldt, R. W., "Osteology of *Eremophila alpestris* [*Otocoris alpestris arenicola*]," Twelfth Annual Report U.S. Geol. and Geog. Surv. of the Territories, 1882, p. 652, pl. iv. fig. 22.

far as this character goes, then, *Ampelis* agrees, as it does in so many other particulars already defined above, with the Oscines rather than with the Clamatores.

We also notice that upon the underside of the superior osseous mandible in the Tyrant Flycatchers the greater portion of that space which occurs between the anterior limbs of the palatines is filled in by a continuous plate of bone, which joins them, while in *Ampelis* (Pl. XVII. fig. 6) this space is open, as we likewise find it in most (or perhaps all) Oscines. In the Tyrants the osseous nasal septum unites with this bony inter-palatine plate above and along its median longitudinal line.

There is but little to detain us upon the superior aspect of the skull; all the three specimens shown in Pl. XVII. figs. 3–5 are rather broad in this region, between the orbital margins, while a moderately well-marked median furrow is to be seen, which is best exemplified in the Thrush, and least so in the Tyrant Flycatcher. All the higher Thrushes have the facio-cranial line fairly well defined on this aspect. I have already remarked that it is barely traceable in *Ampelis*.

Upon the lateral view of the skull of this Chatterer (Pl. XVII. fig. 4) there are two or three points presented of more or less interest. The "pars plana," or antorbital plate, is found to be ample, and completely divides the orbit from the rhinal chamber. In front of this, on either side, is to be found a *freely* articulated little ossicle which I take to represent the *lacrymal*. It shows a constriction at its middle, giving rise to enlarged superior and inferior extremities. The superior end is wedged in between the antorbital plate and the postero-superior edge of the corresponding nasal. Below, its inferior dilatation rests upon the maxillary bar. Behind, it is applied against the anterior surface of the pars plana, while in front it is only in contact with the nasal superiorly, as already described. I find this bone present in *all* of the North-American *Tyrannidæ*, in the true *Corvidæ*, in the genus *Sturnella*, but absent in the *Icteridæ*, in the true Thrushes (*Merula, Hesperocichla*, Pl. XVII. fig. 5), in *Otocoris*, and others. I am not prepared, as yet, to say of what value it will eventually prove to be as a taxonomic character; but in the present instance it is just as well to note that this free lacrymal bone is found in *Ampelis* and the Clamatores (*Tyrannidæ*), and not in the true Thrushes.

The interorbital septum, in the specimen of *Ampelis* before me, is entire, although encroached upon above and behind by the great deficiency or vacuity in that part of the brain-case from which the first pair of nerves make their exit. The foramen for the exit of the second pair is no larger here than the size of the nerve demands. In *Hesperocichla* both of these foramina are considerably larger than is required for the passage of the nerves, while in addition a vacuity occurs in the interorbital septum of the Thrush.

Among the higher types of Thrushes, as in the one just referred to, the bony entrance to the ear looks *directly forwards*, while in the *Tyrannidæ* this aperture looks downwards, forwards, and outwards; in the case of *Ampelis* it is more as we find it in *Hesperocichla*, and in both of these latter forms a conspicuous shell-like covering of bone is developed from behind forwards, which protects this important orifice.

In all the true Passerine birds that I have examined a *quadrate* bone has a well-pronounced orbital process; two facets upon its mandibular foot, the outer being placed transversely, the inner obliquely; while the long diameter of its mastoidal head is also transverse, and supports two articular facets in *Ampelis* and the Oscines, which facets in the *Tyrannidæ* almost completely merge into one.

Turning now to the under view of the skull as shown in Pl. XVII. fig. 6, we observe that the anterior extremities of the palatines (*pl.*) are very slender and wide apart. I have already pointed out how the space between them beneath the superior osseous mandible is filled in by a plate of bone in the *Tyrannidæ*. The postero-external angles of the palatines in *Ampelis* are rounded and projecting, much as we find them in some Swallows, and not very unlike the form they assume in some Swifts.

In this Chatterer the hinder portions of the palatines are considerably extended laterally, and lie principally in the horizontal plane; whereas in such a bird as *Hesperocichla* they are less noticeable for this, while on the other hand their internal and external "*laminæ*" are better developed in this Thrush.

So far as I have examined, in all Passerine birds these bones meet for nearly the entire length down the middle line to the articulation of the pterygoidal heads, and only diverge slightly in front to meet the backward-extending forks of the vomer.

The *maxillo-palatines* (Pl. XVII. fig. 6, *mxp.*) are markedly long and slender in *Ampelis*, and mesially separated by an unusual interval. They slightly exaggerate, however, the conditions in which we commonly find them among the Passeres generally. This remark applies also to the *vomer* (*v.*), which, too, is rather broad, though it bears out its Passerine character in being anteriorly truncate with somewhat produced lateral tips at that extremity to meet the cartilaginous wings of the nasal septum.

Among the *Tyrannidæ*, the palatine heads of the *pterygoids* meet each other beneath the rostrum of the sphenoid; these parts are separated by quite an interval in *Ampelis* (Pl. XVII. fig. 6, *pt.*), as they are also, though to a less extent, in the Thrushes (e. g., *H. nævia*). Here, again, the Chatterer agrees with the typical Oscinine bird. In general form the pterygoids of *Ampelis* agree with those bones as we find them in other Passeres.

In view of the fact that the general characters of the skull of a Passerine bird are well known, and as I believe that I have now thoroughly directed attention to the most important departures therefrom, or similarities therewith, in the foregoing paragraphs, there is nothing else that remains worthy of special record in this skull of *Ampelis*, and the notes thus far made will meet all requirements of reference for what has to follow.

The *mandible* of *Ampelis* is but feebly developed when compared with that bone as we find it in others of this great group of birds. It has more the appearance of a Swallow's jaw than that of either a Thrush or a typical Flycatcher. In general form, however, it is essentially passerine, having an outline not very unlike the mandible of *Otocoris alpestris* (fig. 29 of my memoir upon the Osteology of that Lark). A minute ramal vacuity is present, which is found to be larger in the *Tyrannidæ*, and of a still greater size in *Hesperocichla*. As might be expected, the mandible in the Flycatchers is a much stronger and comparatively heavier bone than it is in these Oscinine types.

22. The *hyoid arches* in our subject are likewise typically Passerine in character, having their several elements delicately constructed, with first and second basibranchial in one piece; with a cartilaginous glosso-hyal, and with comparatively large and free cerato-hyals. *Lanius* is a bird that shows very well the

Passerine pattern for the hyoid arches, and I have elsewhere figured them for that form [*].

The *sclerotal plates* of the eye are composed of separate little pieces of bone in all of these birds of which we have been speaking; but in old specimens in some of the *Tyrannidæ* I have often noticed their tendency to anchylose together, notably in the genus *Sayornis*.

Passeres usually have a small sesamoid bone at the angle of the jaw. I have failed to find it in *Ampelis*, but would prefer examining more specimens before positively announcing its absence. It seems to be invariably present where indicated in all of the higher Thrushes.

23. *Of the remainder of the Axial Skeleton.*—It will be probably a very long time before a sufficient number of the vertebral columns of existing birds have been examined, to ascertain with certainty whether the vertebræ composing them are constant for the several divisions and for the species. When this has been done, and the exact averages ascertained, the result will be no doubt important in assisting to decide doubtful points in classification

The figures recorded in the subjoined Table have in every case only been set down after carefully counting the segments two or three times. With respect to the number of vertebræ in the consolidated sacrum of the pelvis, they are here counted in the adult bird, and consequently must be taken *cum grano salis*, though I believe them to be quite correct.

I am inclined to think at present that the number of free coccygeal vertebræ are liable to vary even in representatives of the same species.

This Table, of course, could easily have been made far more extensive, but in that case would have overstepped the object at present in view. I trust, however, that those who at any time may be engaged in examining the structure of birds will record such data as I have attempted to do here, and only after the most careful counting. To do this, reliance can be placed only upon spirit specimens, or recently killed birds, where there has been no possibility of any of the vertebræ having been lost.

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[*] Shufeldt, R. W., "Osteology of *Lanius ludovicianus excubitorides*," Bull. U.S. Geol. and Geog. Surv. of the Territories, vol. vi. pp. 351–359, pl. xiv. fig. 101. Also same plate and figure in the author's collected memoirs 'Contributions to the Anatomy of Birds.'

Species.	No. of vertebræ before reaching the sacrum.	First free pair of ribs occur on the	No. of vertebræ in sacrum of pelvis.	No. of vertebræ in coccygeal division, including pygostyle.
Ampelis cedrorum	18	12th.	10	9
Hesperocichla nævia......	18	12th.	12	7
Tyrannus verticalis	19	13th.	10	8
Otocoris alpestris	18	13th.	11	7

Of this kind of data I think the greatest reliance is to be placed in the number of *free* vertebræ in the cervical + the dorsal region, as shown in the first column, far more than that shown in the three remaining columns. If we take immature birds, however, chosen just at that point in their development when we can count with certainty *exactly* how many of these segments will enter into the pelvic sacrum, and *exactly* how many will be appropriated by the pygostyle, then the total count of *all* the vertebræ in the column, irrespective of its divisions, will be of value.

24. In both *Ampelis* and *Hesperocichla five* pairs of dorsal ribs possess costal ribs that meet the sternum, and each of these birds have a pair of ribs that spring from the first sacral vertebra, which articulate below with a pair of "floating" costal ribs. This condition also obtains in my specimen of *Tyrannus verticalis*, but in this species there are only *four* pairs of costal ribs that articulate with the sternum. These "sacral ribs" are without epipleural appendages, though these processes are found freely articulated at their usual sites upon all of the true vertebral ribs in the several birds just alluded to.

25. It has been always a matter of some surprise to me that the *pelvis* of a bird has not had that importance attached to it among skeletal characters which has been so universally awarded to the sternum. In many respects its form in some species is far more distinctive of the bird to which it belongs than the sternum can be, and is consequently more reliable. For instance, the sternum of Passerine birds varies but very little throughout the group, and in many cases it would be very difficult to designate the species by simply examining the sternum alone; moreover the

sternum may sometimes assume a different form even for the same species *, which I have never found to be the case in the pelvis.

In Pl. XVIII. fig. 7 is represented the superior or dorsal view (double the size of life) of the pelvis of *Ampelis cedrorum*; it shows very well indeed the general form and characters of this bone as it occurs among the Passeres. Considerable interest attaches, however, to an examination of a transition series of pelves through the Passerine group of birds into other orders wherein marked differences are to be found.

Now in such a bird as *Harporhynchus rufus*, for instance, or any of its genus, the pelvis, when viewed from above, has pretty much the same form as it has in *Ampelis*; but all the processes are more prominent, and all the ridges and crests more conspicuous and defined. This lends to the bone quite a striking appearance in these higher Thrushes. But as we pass through the members of the Oscinine group and into the Clamatores, this bone, although it retains its general pattern, gradually loses this peculiar angularity, and gains in breadth while it becomes comparatively shorter in the longitudinal direction. My meaning will be made clearer when we come to examine, further on, *the pelves of the Swallows and Swifts.*

As to the characters of the pelvis in *Ampelis*, we are to note that, anteriorly on its dorsal side, the inner margins of the ilia are widely separated from the crista of the sacrum; that the pre- and post-acetabular areas are about of equal dimensions, that the former are concave outwards, while the reverse condition obtains with the latter; that the "sacrum" upon this view is roughly lozenge-shaped, and that interapophysial foramina of varying sizes may be found to exist in it.

Upon the lateral aspect it is to be observed, that not only is the acetabulum (as it invariably is in birds, I believe) completely surrounded by bone, but the ischiadic, the obturator, and the obturator space are true foramina, or at least are entirely encircled by bone. In *Tyrannus verticalis* the ischium fails to meet the post-pubis between the obturator foramen and obturator space, and thus convert these openings into veritable vacuities, as is the case in all of the Oscines that I have alluded to elsewhere.

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* For examples of this see my remarks upon the different forms of sternum in the Cathartidæ, "Osteology of the Cathartidæ," in Contributions to the Anat. of Birds, from U.S. Geol. and Geog. Survey, 1882 (Hayden's 12th Annual), pp. 771, 772, where four figs. of sternum of *C. aura* are given.

Otocoris agrees in this respect with the Oscines, as may be seen in my side-view figure of its pelvis (Contrib. Anat. Birds, pl. iv. fig. 22).

The post-pubis in *Ampelis* extends but slightly beyond the hinder extremity of the ischium, which latter meets it behind in a broad foot-like process. These parts in the dried skeleton are very apt to curl outwards, and deceive us as to the true shape of this part of the pelvis during life; so that it is only in fresh specimens that we can gain a correct notion of this bone in most Passeres.

This post-preparatory deformity of this part of the skeleton has been taken into consideration in figure 7, and duly corrected.

The coccygeal vertebræ and pygostyle in *Ampelis* require no special description, for they agree in all essential particulars with the parts as found among the Oscines generally. They are very well shown in my figure of the skeleton of *Otocoris*, alluded to above.

In *Tyrannus* the coccygeal vertebræ are comparatively very large and their diapophyses very broad.

26. As we would naturally be led to suspect, the *sternum* of *Ampelis* is, of course, a thoroughly Passerine one, having the characteristic bifurcation of the manubrium; the lofty costal processes, the well-developed and deep carina, the cordate-shaped notch on either side of the xiphoidal extremity, and the *five* facets upon either of its costal borders.

Among the American *Tyrannidæ* the sternum has essentially the same shape, but it has only *four* facets for the hæmapophyses upon each of its costal borders.

A fuller description of this bone will not be required here. I have already published a pectoral view of a typical Passerine sternum elsewhere (Coues's 'Key,' 2nd ed. fig. 58), and other forms of it may be seen in my figures of the sterna of *Lanius*, *Otocoris*, and others, in memoirs already cited.

This bone will be taken into consideration again, further on, when we come to treat of the sterna of the Swallows, Swifts, and Humming-birds.

27. The elements of the *shoulder-girdle* in *Ampelis* more closely resemble those parts in the typical Oscines than in the Clamatores. In form and arrangement they make scarcely

any perceptible departures from such structures as we find them in *Lanius* (see Contrib. Anat. Birds, pl. xiv. figs. 93, 94, 95, and 100).

The blade of a *scapula* is sabre-shaped, long and narrow, and anteriorly abuts against the laterally compressed and expanded end of the furcula of the corresponding side. The shaft of a *coracoid* is long, slender, and subcylindrical in form. Its clavicular head is tuberous, being hooked forwards and inwards.

The *furcula* typifies the U-shaped pattern of this bone, and I would especially call attention here to the form of its hypocleidium in *Ampelis*. This process is a long, *suboval*, laterally compressed lamina of bone, directed upwards and backwards towards the manubrium, when the girdle is articulated *in situ*. My figures, already referred to above, of *Lanius* and *Otocoris* show very well this form of the hypocleidium of the furcula.

Now in *Tyrannus verticalis*, taken as representing the Clamatorial group of birds, this process of the furcula is nearly circular in outline, and *decidedly smaller*. Little points of this kind, when they are found to be constant, should be borne in mind here, for they will surely arise again, when we come to see how such characters are exhibited among the Macrochires.

28. *Of the Appendicular Skeleton.*—Not only in the case of *Ampelis*, but with the Passerine birds generally, the composition, forms, and structure of the skeleton of the limbs are so well known, that I will not here attempt to add anything to this part of my subject. So far as the bones are concerned, I fail to find, even upon close scrutiny, any reliable set of characters that one could use with certainty in deciding in any case whether the *skeleton* of a leg or a wing belonged to an Oscinine or a Clamatorial bird.

When we come to deal further on with the skeletal limbs of the Macrochires and others, where such characters as are present in these parts in the Passeres can be, if ever, usefully compared, it will then be ample time to bring them forward for comparison, and decide whether these structures afford anything helpful in determining affinities. To recapitulate here the well-known points in the skeleton of the limbs in a Passerine bird would, I am sure, avail us nothing.

Suffice it to observe that in its organization *Ampelis* is by the majority of its structural characters an Oscinine bird, though it also presents here and there in its economy traces of a Clamatorial type, such as is shown in its free lacrymal bone and a few other minor points. I fail to find anything in its morphology that especially connects it with the *Hirundinidæ*. As I anticipated, however, the brief synopsis of its structural characters goes to show, in support of the views already elsewhere expressed by Garrod, that *Ampelis* has an organization of an average Oscinine bird, by which I mean not typically so, and consequently will be of service here as an aid to comparison as we proceed.

OSTEOLOGY OF TROGON MEXICANUS AND TROGON PUELLA.

As will be seen by my tabulated list of material, I am indebted to Dr. Sclater for two excellent skeletons of these Trogons. He kindly had them prepared for me, and sent by post in ample time to use in the preparation of the present memoir.

In my first paper upon the Macrochires, I stated that I wished to compare the skeleton of a Trogon with one of a Humming-bird (P. Z. S. 1885), as Forbes had found in them a peculiar structure of the palate, which led me to believe that there might be other points in the skeleton of one of these birds which would indicate some remote affinity perhaps with the Trochili. Hence it was with no little interest that I opened the package that Dr. Sclater had sent; but my eyes had no sooner fallen upon the two neatly prepared specimens it contained, than the exclamation was forced from me, "Why, they are Caprimulgine Cuckoos!"

How well this first impression will be supported by a careful examination of the skeleton in detail we will now see.

In figuring the osteology of the Trogons, based upon these two specimens, I chose the skeleton of *T. mexicanus* for all my drawings. This I did as it no doubt agrees in all particulars with the skeleton of our own Trogon, *T. ambiguus*, and I have long been desirous of contributing to the knowledge of the osteology of that lone species of the genus in the United States avifauna.

Practically, however, a description of the skeleton of *Trogon mexicanus* will answer very well for the skeleton of *T. puella*, for there is but very little difference between them. I must not, however, be understood to say that the difference in the skeletons of these two species is of so slight a nature that we cannot readily distinguish them; for if a series of each were mixed up before me, there would be no difficulty whatever in rapidly selecting the skeletons which belong to either of these two species. As I proceed with my detailed descriptions, I will point out the more marked of these differences, while my observations must be considered as applying directly to the skeleton of *T. mexicanus*, unless otherwise specified.

Of the Skull (Pl. XVIII. fig. 8, and Pl. XIX.).—Viewing this part of the skeleton from above, we find that a strong transverse line separates the superior osseous mandible from the fronto-lacrymal region, which latter arches upwards and backwards from it. This superior mandibular portion of the bony beak is rather low from above downwards, broad at the base, tapering rapidly to the tip, while its osseous tomia are sharp, and the culmen is a graceful, rounded, and unbroken arch from the frontal region to the tip of the beak. The narial apertures at its sides face upwards and outwards; they are large, of an elliptical outline, and with smooth, rounded edges.

Each *lacrymal* bone is a somewhat slender, peculiarly-shaped element of an *f*-like form, which freely articulates by its superomesial surface or moiety with a vertical facet offered by the corresponding frontal. Its upper end rises above the surrounding surface of the skull, while its lower extremity fails to reach the quadrato-jugal bar below.

The region between the orbital peripheries on the superior aspect of this skull is very narrow, and presents a shallow longitudinal furrow. Posterior to this part the parietal region is characterized by two laterally placed roundly convexed eminences, with a rather better marked median longitudinal track between them, being the continuation of the furrow just alluded to in the interorbital region.

Viewing the skull of this Trogon upon its lateral aspect, this marked rounding of the parietal region lends to it rather an unusual configuration for the cranium among birds.

Upon this view, too, we must note the rudimentary condition of the sphenotic process, while the squamosal apophysis below it is large and conspicuous. The interorbital septum, *per se*, is entire though very thin, while, on the other hand, the foramina at the posterior aspect of the orbital cavity are far larger than is required for the nerves to which they severally give passage; especially is this true of the superior vacuity. In both of these Trogons, however, although these foramina are very large, they still retain their individuality, and do not merge with each other.

At the upper part of the interorbital septum we observe, plainly marked, the track for the first pair of nerves. It does not in either of these specimens communicate, through a thinning of the walls, with a similar track in the opposite orbital cavity, as we often see in other birds.

Anteriorly the partition between the orbit and rhinal chamber is composed of an exceedingly small *pars plana*, and of a thin membrane which stretches from it to the already-described lacrymal bone. In the dried skeleton, after the membrane has been removed, the communication between these two cavities is unusually free, more so than in any other bird that I happen to recall at the moment. The periphery of the orbit is sharp for its anterior two thirds, but becomes rounded off as it passes backwards over the anterior wall of the brain-case in line with the lateral processes of the skull.

Sutural traces among the original elements composing the quadrato-jugal bar are hardly perceptible, and this osseous rod is quite straight from one end to the other, its tip only being bent up as it articulates with the quadrate.

Each *nasal* bone, in this skull, has completely merged with the premaxillary and frontal of the same side, so that all traces of its original borders are obliterated, and it has become thoroughly incorporated in the conformation of the osseous superior mandible.

We will now turn to the underside of the skull of *Trogon mexicanus*, where we find many points of interest presented for examination. Approximately speaking, the majority of structures observable upon this aspect are found in the same horizontal plane, which plane nearly includes the entire foramen magnum, and the anterior moiety of this opening may be said to lie in it.

The roof of the anterior half of the mouth is composed of a continuous plate of bone contributed by that portion of the premaxillaries. Into the hinder border of this plate we find the anterior and dilated ends of the palatines merging. At this point these latter bones are quite close together; posterior to it, however, an oval, longitudinal interpalatine space occurs through which we can see the osseous nasal septum and the vomer.

These latter structures will be alluded to again after completing the description of a palatine bone.

The anterior half of a palatine is a narrow ribbon of bone placed horizontally, dilated at its further extremity, which, as has already been said, blends with the horizontal portion of the corresponding premaxillary. The posterior division of the bone feebly develops an inner and an outer carination, the "postero-external" angle being completely rounded off.

In the median line, beneath the basisphenoidal rostrum, these palatine bones meet each other, and in front the vomer, for their entire lengths, a union which, in both *T. mexicanus* and *T. puella*, seems to amount to an absolute anchylosis.

If this prove to be universally the case in the skulls of fully adult Trogons, it need not surprise us, for when we come to the Humming-birds there will be another peculiar anchylosis to be described that is occasionally to be found in their skulls.

Now the *vomer* (fig. 8, *v.*) in both of these Trogons is a rather short subcylindrical rod with a bluntish point. This point rests directly upon the posterior free edge of the osseous nasal septum (*n.s.*).

This intimate relationship between the vomer and nasal septum in the Trogons led the late W. A. Forbes into an error, which will be at once evident upon an examination of his drawing of these parts in *Pharomacrus mocinno* (P. Z. S. 1881, p. 837). At least it does not hold quite true in the species at hand; and I suspect that Forbes, in examining alcoholic specimens, included this thin posterior edge of the nasal septum with the anterior tip of the vomer, giving it that "thin and filiform" appearance to which he alludes. This slight error might easily be made by that kind of an examination, when in a dried skull, such as I have before me, these parts would be better distinguished. His description, however, in the contribution above referred to, is a marked improvement upon that by Professor Huxley, which it was written to correct; and the former writer was fully aware of the fact that the nasal septum in the Trogons ossified. In my specimen of *T. mexicanus* this plate has a large vacuity in its centre, while in *T. puella* it is entire.

The tips of the *maxillo-palatines* do not show in the interpalatine median space, upon this view of the skull, as they are said to do in *P. mocinno* by Forbes in the paper just quoted. (Compare figure in P. Z. S. 1881, p. 837, and fig. 8 of the present paper.) Indeed, I can fully verify Forbes's statement that the Trogons are not desmognathous birds, but very decidedly schizognathous; and, furthermore, I am inclined to believe that there is a fair measure of truth in the words of this anatomist when he stated "that the structure of the palate has not that unique and peculiar significance that has been claimed for it in the classification of birds." My eyes were opened to this fact more thoroughly than ever when I came to find such a bird as *Chordeiles* completely desmognathous, while certain forms of *Caprimulgus* and *Phalænoptilus* were ægithognathous, as defined by Professor Huxley in his well-known "Contribution to the Classification of Birds" (P. Z. S. 1867, p. 468).

Large *basipterygoid processes* are developed both in *T. mexicanus* and *T. puella*, which in each case are articulated with ample facets upon the pterygoids themselves.

The palatine heads of the *pterygoids* are widely separated in the median line; while, as I have already stated, the palatines opposite their place of meeting them are in contact to their very ends. The outer edge of a pterygoid is quite sharp, while this bone is compressed from above downwards and articulates in the most usual manner by a ball-and-socket joint with the corresponding quadrate.

A *quadrate* develops a long orbital process with dilated tip. Its mandibular foot supports two facets upon it, which are separated from each other by an intervening valley. There are also two such facets upon the squamosal head of the quadrate. Otherwise this element is notable for the unusually long apophysis it offers laterally to meet and articulate with the posterior end of the quadrato-jugal bar.

The underside of the basisphenoidal rostrum is much thickened and rounded for its entire length, thus affording a broad sliding surface for the articulation of the pterygo-palatine ends. Barely an apology for a bony scale overhangs the entrances to the Eustachian tubes, while immediately behind them the base of the cranium is very broad between the aural apertures. The occipital condyle is comparatively very small indeed, though the subcircular foramen magnum is fully up to the average in point of size. Upon either side of it, we find the usual group of foramina for the passage of nerves and vessels (Pl. XVIII. fig. 8).

I have made no special examination of the interior of the cranial casket in these birds, but we are to note the great delicacy of the walls of this part of the cranium and how thin they are. Air seems to gain access to the major portion of the skull in both of these specimens, including the quadrates and perhaps the pterygoids.

I am reminded in my examination of the *mandible* of *Trogon* of the form this bone assumes in some of the smaller American Owls, as *Speotyto* for example. Its articular ends are rather large, being bluntly pointed behind, and having long, sharp, inturned mesial tips.

The borders of the rami are rounded off, while their height remains quite uniform for the entire length of the jaw. Upon their outer aspects, for the posterior moiety of each, an excavation occurs, at the middle of which, on either limb, is seen a small ramal vacuity.

The symphysis is deeper by half again than either ramus, and the superior border above it is sharpened. In general outline the mandible of a Trogon is broadly V-shaped, and this bone is partially pneumatic.

So far as these two specimens are concerned, I find that *T. puella* differs from *T. mexicanus* in its skull in having an entire osseous nasal septum, a rather wider frontal space on the superior aspect of the skull between the orbital margins, the parietal eminences are not so lofty, and a better developed osseous lip protects the entrance to the Eustachian tubes. Their mandibles are essentially similar.

Of the Hyoid Arches.—As might be expected, these practically present little or no difference in the two species of Trogons before me. The hyoid arches in *T. mexicanus* are small as compared with the size of the skull of the bird, the thyrohyals barely curving up behind at all. The apparatus as a whole reminds me not a little of the hyoid arches in some of the smaller American Owls (*Glaucidium*).

The glossohyal is formed entirely of cartilage, while the ceratohyals have ossified. In this adult bird the first and second basibranchials are joined in one piece by anchylosis, the ceratobranchial of the thyrohyals apparently articulating in the lateral sockets at their point of union.

Cartilaginous tips finish off the hinder ends of the epibranchials, and these elements of the "greater cornua" are nearly straight longitudinally, nor are they notably curved in the direction of the median plane of the body.

Of the Remainder of the Axial Skeleton.—From a careful examination of the vertebral column of both of these Trogons. I am enabled to present the subjoined table of data in regard to this part of their skeletons and in which both these species agree :—

Number of cervical vertebræ without ribs	12
The first cervical vertebra supporting a pair of free ribs =	13th.
The first vertebra of the column wherein the ribs articulate with the sternum by means of costal ribs is the	14th.
Number of true ribs thus articulated	4
Number of hæmapophysial facets on sternum	4
Number of true dorsal vertebræ	5
Number of vertebræ consolidated with pelvis	12
Number of caudal vertebræ (free) including the pygostyle are	7

It will be noted from this table, of course, that the pair of vertebral ribs attached to that vertebra here called the fifth dorsal have costal ribs that do not meet the sternum, but articulate with the hinder borders of the last pair of costal ribs that do.

There is also a pair of ribs that spring from beneath the fore part of the sacrum, articulating with the first or anterior vertebra, that becomes consolidated with the pelvis. These ribs also meet short and free hæmapophyses below, which in their turn articulate with the posterior margins of the pair of first or leading "floating ribs" referred to in the foregoing paragraph.

Neither the last pair of dorsal vertebral ribs nor the sacral vertebral ribs possess epipleural appendages ; consequently we have but five pairs of true vertebral ribs that do support these processes.

And, further, we ascertain from the table that the total number of free vertebræ in the column before we arrive at the first one that becomes consolidated with the pelvis is 18.

Among the principal characteristics of the first twelve vertebræ of the column we are to note that the usual outstanding processes, such as the neural spines, parapophyses, and hyapophyses, are but feebly developed, being for the most part short and inconspicuous. The superior spines of these vertebræ are most prominent in the axis and next following three or four segments.

In neither of the specimens examined does a perforation exist in the cup of the atlas, while the neural arch of this vertebra is comparatively narrow.

The hypapophysial processes of the fifth, sixth, seventh, and eighth cervical vertebræ part mesially in order to form a canal for the protection of the left carotid artery, the only one present in these birds (Garrod), as it passes to the head.

Upon the last few cervicals, and upon the first two or three dorsals, very well-developed hypapophyses are to be found, which may become tricornuted towards the latter end of the segments specified (*T. puella*).

Diapophyses of the dorsal vertebræ are notoriously broad, with their outer extremities rounded, being considerably wider even here than the bodies of the ribs that articulate beneath them (*T. mexicanus*).

Below, the centra of these dorsal vertebræ are deep and much compressed laterally; their median, longitudinal, inferior lines being almost cultrate in character.

The dorsal neural spines are all nearly of the same height, but, on the whole, rather low in point of altitude. Their superior rims are thickened, and interlock at their anterior and posterior ends. These five dorsal vertebræ, although freely articulated, are very closely moulded upon each other, and consequently the mobility of this division of the column is somewhat limited.

Facets for the vertebral ribs are here, as usual, found for each pair just within and posterior to the anterior margins of the centra of the respective vertebræ at their lateral aspects.

Thus far in the column of these Trogons the plan of articulation seems to be truly "heterocœlous," *i. e.* the ends of the centra present saddle-shaped facets, which in turn lock with a counter-placed one on the opposed face of the vertebra next behind.

Of the Sternum.—Leaving the vertebral column for the moment, we will turn our attention to this bone. There is a good deal in the sternum of *Trogon* to remind us of the same part of the skeleton in *Geococcyx*; of which we may at once satisfy ourselves by comparing the figures of the bone as it is found in these two forms and shown in my plates. Figures of the sternum of *Trogon mexicanus* illustrate this memoir (Pl. XIX. figs. 12, 13), while corresponding views of it for *Geococcyx* are to be found in the plates of my contribution upon the osteology of *G. californianus* in the 'Journal of Anatomy and Physiology' for 1886.

Among the Trogons the sternum is short, and, when taken in comparison with the size of these birds, rather expansive behind, where it shows two deep rounded notches on either side of the carina. The outer pair of lateral processes which are thus produced have expanded posterior ends. As already stated, each costal border supports four small transverse facets for the hæmapophysial ribs, which are crowded pretty close together. Beyond these the costal processes are of a quadrate outline on either side, and are directed upwards and very slightly forwards as conspicuous projections.

Tribedral in form and rather inclined to bifurcate at its summit, the well-developed manubrium is cultrate mesially in front and this prominent apophysis rears itself upwards and forwards from its usual site, as seen in birds generally where it is present. Immediately behind it are the coracoidal grooves, which, though narrow from above downwards, extend far out laterally and meet, or very nearly meet, at the middle point posterior to the manubrial base.

The keel of this bone is comparatively deep and extends the entire length of the sternal body, while its inferior border is gently convex for its entire length forwards, and its anterior one considerably concave. At their intersection in front the carinal angle is bluntly rounded off.

From the fact that the xiphoidal processes are spreading in character and the sides of the sternal body uniformly raised, not an inconsiderable concavity is enclosed on the thoracic aspect of this sternum; and, as is usually the case in birds of this form, the pelvis above is seen to be correspondingly widespread, indicating roomy abdominal and thoracic cavities within their enclosure.

Pneumaticity is not a prominent feature of the sternum among the Trogons, although a few insignificant foramina do admit air to this bone where such openings ordinarily occur.

Of the Shoulder-Girdle (Pl. XIX. fig. 13).—We find the *os furcula* to be of the U-shaped variety, with a well-formed hypocleidium of a rounded outline at its clavicular junction beneath. The limbs of this bone are slender, while the heads are somewhat expanded and much compressed laterally. They rest against the mesial aspects of the superior tuberosities of the coracoids, and on either side extend backwards to the scapula, which they overlap to some extent, resting upon the upper side of the clavicular process of the bone.

A *scapula* here makes the usual articulation with a coracoid and offers the proportional amount of articulatory surface to the glenoid cavity. Its blade is narrow, rather long, of an equal width throughout, and compressed from above downwards. Posteriorly its extremity is obliquely truncate from within outwards, while the end itself is slightly curved in the same direction.

Either *coracoid* is characterized by a very extensively expanded sternal extremity of a quadrilateral outline, and of no great thickness in the antero-posterior direction. The shaft of the bone above this dilated end is rather slender, subcylindrical, being compressed from before backwards, and is evidently hollow. Its summit is not conspicuously enlarged, though it is rather more tuberous than we find it in such a group, for instance, as the Passeres. The head is directed in the articulated skeleton upwards, forwards, and inwards. Its scapular process is not very wide, for the scapula projects over it a little, both mesially and to its outer side; while in the former direction it stands between its superior articulating edge and the corresponding head of the clavicle, *i. e.* the scapula does. Air seems to gain access to the shafts of the coracoids, and perhaps to some extent to the extremities of these bones; but, so far as I have been able to discover, neither the *os furcula* nor the scapulæ possess any pneumaticity.

Neither of these Trogons possess, upon either side, the little ossicle at the shoulder-joint known as the *os humero-scapulare*, though it is just possible that it may in every case have been removed by accident during the preparation of the specimens.

Of the Pelvis and the Coccygeal Vertebræ.—No marked differences distinguish the pelves of these two species of Trogons. There is some general resemblance between the pelvis of *T. mexicanus* and the bone as we find it in certain Caprimulgine birds, though when we come to the details in such a comparison the divergence is sufficiently marked.

Viewing the pelvis of *Trogon mexicanus* from above, we observe that the preacetabular area is considerably more extensive than is the postacetabular (Pl. XIX. fig. 14). The outline of this upper surface is somewhat quadrilateral, its average width being about equal to its average length. In this specimen there are no existing vacuities among the diapophyses of the sacral vertebræ. One or two extremely minute ones are found in these positions in the specimen of *T. puella* among the ultimate vertebræ.

Marked lateral extension characterizes the transverse processes of the sacral vertebræ, more especially those three which are about opposite the acetabulæ; those in front and behind these are proportionately graduated off; and although, as I have observed, no foramina exist among them, the overspanning bone is in some places exceedingly thin.

The anterior margins of the ilia are obliquely truncate from a direction within outwards and backwards; and these borders have a delicately thickened rim. Internally, the margins of these bones fail, on either side, to meet the consolidated neural crest of the leading sacral vertebræ, there being short "ilio-neural canals" present in the pelves of these Trogons, of some two millimetres in width.

As to the superficial form of the several areas of this pelvic roof, we find the anterior moieties of the ilia to be concave; the posterior and smaller ones convex; and the middle area, formed by the sacrum, is an ample lozenge in its general outline.

Turning now to the lateral aspect of the pelvis of this Trogon (Pl. XIX. fig. 13), we are to observe that the anterior or pre-acetabular division of the bone lies in the same general plane with the longitudinal axis of the dorsal vertebræ, while there is a gradually increasing droop of all the hinder division of the bone, until we arrive at the slender post-pubic element, the posterior extremity of which turns slightly inwards and upwards.

Comparatively speaking, the acetabulum is rather small, and its base is deficient in bone, being so rendered by the usual circular vacuity there. The antitrochanter occupies here its common site, above the acetabulum, and faces forwards, downwards, and a little outwards. Behind it again we find an ample and subelliptical ischiadic foramen, situated thoroughly within the borders of the surrounding bone. The obturator space and the obturator foramen have so merged with each other that scarcely a distinguishing trace of separation can be detected between them.

A long subelliptical foramen is thus formed, the lower margin of which is bounded, as usual, by the narrow bar of the post-pubic element, as it sweeps by to the rear. This foramen is closed in behind by the foot-like process of the ischium which descends to meet the post-pubis, the latter extending for some three or four millimetres behind it, and thereafter taking a direction already described in a foregoing paragraph.

On the underside of this pelvis we find its "basin" to be wide and capacious, though not at any point correspondingly deep. The first three or four sacral vertebræ throw out their lateral processes to abut against the nether surface of the ilia, on either side, their extremities co-ossifying with the same; while the leading vertebra of all of the sacrum, as I have already said above, supports a pair of freely articulating ribs. A strong pair of lateral processes come off from the sacrum opposite the acetabulæ, and by abutting against the inner pelvic walls just above these circular apertures, they form strong braces to this part of the pelvis. Other members of the class frequently possess this feature. Now the posterior border on either side of this pelvis shows scarcely any mark to distinguish the union of the ilium and ischium, beyond a slight elevation at the usual point; in some birds, as we are aware, a notch defines the place.

Among the coccygeal vertebræ of the tail the transverse processes are all long and spreading, the last three being conspicuously so. Their neural spines are low and not prominent; while only the ultimate vertebra supports a bifid hypapophysis beneath its centrum.

To complete my account of the axial skeleton of a Trogon, it may be noted that the *pygostyle* is of a rhomboidal outline, with a considerably thickened base, and a perforation in its plate-like part near the supero-anterior angle.

Of the Appendicular skeleton; the Pectoral Limb (Pl. XIX. figs. 12–14).—No very striking feature distinguishes the *humerus* of one of these birds from the same bone as we find it in a considerable number of the Passeres. It seems to be thoroughly pneumatic, and the fossa that harbours the foramina occupies its usual site, and is surrounded in the usual manner by the ulnar crest at the proximal extremity of the bone.

The radial crest is rather low; its free border being long and convex, and the plate itself being bent palmad, as we so commonly find it among Passerine birds.

Coming to the shaft, we find it to be of a subcylindrical form, somewhat compressed laterally, and possessing the usual sigmoid curve, only in a moderate degree.

Nothing worthy of special record marks the distal extremity of this humerus, it being tuberous only to an extent in harmony with the general size of the bone; and upon its palmar aspect are to be found the two usual tuberosities for articulation with the bones of the antibrachium.

In neither of the Trogon skeletons at hand do I find any sesamoid bones present at the elbow-joint; but it is just possible that these birds may possess them, and that in the present instance they have been lost in the preparation of the skeleton; I am inclined to believe, however, from the general appearance of the dried ligaments and other structures that have been retained in one specimen, that the Trogons do not have these ossicles at the elbow-joint.

Turning to the bones of the forearm, we observe that the shaft of the *radius* is very slender and nearly straight. Its extremities are comparatively but slightly expanded, and on the whole this bone is not so powerfully developed as we find it in many birds of the same size. The interosseous space between it and the ulna is ample, but is largely due to the curvature in the shaft of the latter bone. The *ulna* has the usual form as we find it in some of the Passeres. Its olecranon process, however, is not conspicuous, while the shaft is smooth, subcylindrical, and devoid of the row of papillæ for the insertion of the quill-butts of the secondaries of the wing, so prominent in some birds, as, for instance, many of the *Picidæ*.

Radial and ulnar ossicles compose the carpal joint, and make the usual articulations with the surrounding bones. I am unable to discover any sesamoids about this joint, and am of opinion that none exist.

Extending our observations to the hand, we may note the peculiar form of its main bone, the carpo-metacarpal. This peculiarity does not consist in any radical change of its form as it is found to be in most birds, but of the unusual width it assumes at its distal end, in the antero-posterior direction (Pl. XIX. fig. 13). The increase of surface thus gained is for the accommodation of the articular facet for the single and terminal phalanx of mid-metacarpal digit, here disproportionately large as compared with the bones of the other two phalanges.

Pollex phalanx is small, slender, and trihedral in form; it is not provided with a claw at its distal extremity.

A very similar joint is the distal phalanx of index digit, and this, too, is without a terminal claw.

The proximal bone of this finger has the general form it assumes among birds, but in the present instance the expanded blade-like portion behind is very thin, its surrounding margin only being thickened to lend it the proper support.

When we come to measure the lengths of the bones composing the pectoral limb in this Trogon, we find that the humerus is 3·1 centimetres long, the ulna 3·6; and the skeleton of manus, measuring from the summit of the carpo-metacarpus to the distal apex of the last phalanx of index digit, 3·0 centimetres long.

Of the Pelvic Limb (Pl. XIX. fig. 13).—Trogons have a thoroughly pneumatic femur, and a large foramen or two to admit the air are found upon the anterior aspect, near the summit of the bone, between the trochanter and the head. I am not quite certain but that the tibia also possesses a moderate amount of pneumaticity, as the shaft is completely hollow and the bone has the general appearance of a pneumatic one. However, I have failed to discover the presence of the foramina in this part of the skeleton of the leg. As for the fibula and the remaining skeletal parts of this limb, they are entirely devoid of this feature.

Returning to our examination of the femur, it is to be noted that the trochanter is but feebly pronounced, and does not rise above the summit of the bone. The caput femoris is globular and quite sessile with the shaft. We can scarcely discern any pit whatever upon its superior surface to lodge the attachment of the ligamentum teres. Descending to the shaft we find this part of the bone nearly cylindrical in form, very smooth, and quite straight. At its distal extremity the condyles are rather small comparatively; the external one being situated lower, and at the same time somewhat more prominent than the internal one.

Trogons possess a very well-developed *patella* of a subcordate form, it being fully twice as wide as it is deep.

Regarding the *fibula*, we find that it presents little or nothing worthy of special note. Feebleness of development characterizes this bone in the Trogons throughout. Its head is small and the shaft slender, the lower end of the latter being free from the tibia, and descending to a point about opposite the junction of the middle and lower thirds of its shaft. Scarcely any evidence exists of the presence of the tubercle for the insertion of the tendon of the biceps muscle, a feature which is quite prominent in some birds.

Next, passing to the consideration of the *tibia*, we find its shaft to be nearly straight, being but slightly convex forwards; while for the greater portion of its midcontinuity it is of a subcylindrical form, changing only as it approaches its enlarged extremities. At the proximal end of the bone the pro- and ectocnemial ridges on its anterior aspect are considerably suppressed, and soon merge into the shaft below; they are nearly of equal size, and the cnemial crest above them does not rise above the tibial summit.

Although the condyles at the distal end of the bone are very similar to these protuberances as they are commonly found in the majority of small birds, they are yet peculiar in having between them, below and behind, a mid- and well-marked longitudinal ridge, constituting a feature that at this moment I do not remember to have noticed among the tibiæ of the class.

On the anterior aspect of this tibia, just above the condyles, we notice the usual longitudinal tendinal groove, spanned at its lower part by an osseous bridgelet thrown directly across it.

The *tarso-metatarsus* has a length equal to rather more than half the length of the tibia, while the calibre of its shaft is about one third less than that of the latter bone. This tarso-metatarsal shaft presents three plane and ungrooved surfaces, an anterior one and two lateral, or rather postero-lateral, ones. The summit of the bone is moulded in the usual manner for articulation with the tibial condyles. Behind the proximal extremity of the bone we find a fairly well-developed hypotarsus, vertically pierced by two tendinal canals placed side by side.

Passing to the distal end of the tarso-metatarsus, we find the trochleæ so disposed as to accommodate themselves to the zygodactyle condition of the podal digits, which consists, as we know, in Trogons of a permanent reversion of the second toe.

These digits have their bony phalanges arranged upon the most usual plan as we find it in the vast majority of living birds, *i. e.* 2, 3, 4, and 5 joints for the first, second, third, and fourth toes respectively.

Considered as a whole, although the skeleton of the foot of this bird is in due proportion with the rest of the limb, it nevertheless strikes us as being rather a delicately formed structure. The accessory metatarsal possesses a shape usually assumed by it among birds, but in the present instance makes a very close articulation with the shaft of the tarso-metatarsus at its most usual site.

Measuring the lengths of the several bones of this pelvic limb, as we did in the case of the pectoral one, we find that the femur is 2·3, the fibula 2·1, the tibia 3·3, and the tarso-metatarsus 1·6 centimetres long.

Without measuring the several lengths of the joints of the pedal digits of a Trogon, I am enabled to say that they are quite as harmoniously proportioned as are the corresponding phalanges of the average foot of any Passerine bird that I have ever examined.

This completes my description of the skeleton of *T. mexicanus*, and, as observed, it will apply with almost equal exactness to the skeleton of *T. puella*. In proceeding with my account I have been careful, I believe, in every instance to point out any constant character that seems to distinguish them; and no doubt my description will practically answer for other nearly related species of this handsome group of birds.

It seems scarcely necessary to tabulate the salient features of the osteology of this Trogon here, as my brief account presents but little more than an enumeration of the essential characteristics. It will therefore be omitted, in the belief that the several figures illustrating my text and the description will be amply sufficient even for convenience of reference.

Comparing these osteological characters of *Trogon* with the corresponding ones of such a Humming-bird as *T. Alexandri*, as I presented the latter in my former memoir, P. Z. S. 1885, it will at once become evident to us that, so far as the skeletology of the two forms is concerned, there is absolutely little or nothing that mutually characterizes them.

So much for the comparative osteology of Humming-birds and Trogons, but this will not exactly apply to some other groups of birds, such, for example, as the Cuckoos and Nightjars; and I will now proceed to draw a few comparisons among some of them.

I regret to say that the only Cuckoo-like bird I have at hand is *Geococcyx californianus*, and, as stated above, I have already published an account of its osteology in the 'Journal of Anatomy.' I did have, not long ago, a fairly good skeleton of the Yellow-billed Cuckoo (*Coccyzus americanus*); but Prof. Parker was at that time in search of all the Cuculine birds he could procure, and it gave me great pleasure to forward it to him along with a few others that I had collected, in response to his request for such material.

The characters of that skeleton have escaped me, but the reader can easily compare such forms as he may have at hand with what follows.

My former memoir (P. Z. S. 1885) contains an extensive account of the osteology of *Chordeiles* and *Phalænoptilus*; so in the present connection I may point out what has been already ascertained in regard to a comparison of these Caprimulgine forms and *Geococcyx* with the Trogons. Thanks to my friend Mr. Sage I have before me a fine alcoholic specimen of our American Whip-poor-will; but I do not intend to dissect that until we enter upon the next section of this memoir, wherein it will constitute my type for the general anatomy of a Caprimulgine bird.

A comparison of the skulls of *Trogon*, *Chordeiles*, and *Geococcyx* need not detain us long, for they have but very few characters in common. With respect to the skulls of *Trogon* and *Geococcyx* they may be dismissed by stating that they differ from each other in every essential particular, beyond the fact that they are both skulls of birds.

This difference is quite as great when we come to compare the skulls of *Chordeiles* and *Geococcyx*, for here, too, it would be very difficult, if not quite impossible, to pick out a single feature in the one that would in any way be comparable to the corresponding one in the other.

Except for the fact, as stated, that they are both skulls of birds, they are totally unlike.

Not nearly so much so is this the case with *Trogon* and *Chordeiles*; for, different as the skulls of these two forms really are, I think I can see a certain resemblance between them, slight as it is.

Still even here, at the best, it is little more than a superficial likeness; they have, however, in common the basipterygoidal processes, if nothing beyond that. Their mandibles, as we know, are entirely dissimilar. Notwithstanding this, it would be far easier for us to conceive that a Trogon's skull was a very much modified Caprimulgine one than it would be to picture any relation between it and the skull of *Geococcyx*.

With these facts before us we are not surprised to find, what is really the case, that the osseous hyoid arches of these several types are also of very different patterns, and do not suggest to us any special relationship of their owners.

To sum up then, so far as the skulls of these birds are concerned. Had we no other part of their structure to guide us, I think we should be fully justified in placing them in separate orders of birds. But let us still further compare the characters of their osseous structures and pass to a consideration of the remainder of their axial skeletons.

First let us take a glance at the number of vertebræ in the spinal columns of the several birds in question, irrespective of any special characteristics these vertebræ may possess in themselves. For I wish it to be distinctly understood that although

Species.	Number of vertebræ in the cervical portion of the column that are without free ribs.	The first vertebra that bears a pair of free ribs.	The first vertebra whose ribs connect with the sternum by costal ribs.
Trogon mexicanus.........	12	13th (without unciform processes).	14th
Chordeiles texensis.........	11	12th (with unciform processes).	13th (14th in *P. Nuttalli*).
Geococcyx californianus ...	12	13th	15th

Species.	Number of dorsal vertebræ connecting with sternum.	No. of vert. in sacrum and the sacral ribs.	No. of free tail vertebræ, including pygostyle.
Trogon mexicanus.........	4 (and one more dorsal vert. that does not so connect, making 5 dorsals).	12 There is one pair of sacral ribs.	7
Chordeiles texensis	3	10 sacral ribs join sternum.	6 (5 in the Whip-poor-will)
Geococcyx californianus	3 (and one more dorsal vert. that does not so connect).	11	5

I place the just amount of weight that should attach to the *number* of these segments in the spinal column of any bird, I think it should be borne in mind that these vertebræ are as much entitled to be considered in the light of the special form each or any of them may assume, as is any other part of the skeleton.

The day may yet come when the question of the exact affinity of avian forms (or any other class of vertebrates for that matter) will have arrived at such a point of refinement as to require that even the morphology of *each vertebra* shall be known, to assist us in correct decisions. In the table which I here introduce (p. 335) the number of ribs and some few other points which I deem it well to compare have been entered.

So far as we are able to judge by a comparison of these, it would seem that, taking into consideration the kind of data presented, *Trogon* comes nearer to *Geococcyx* in its vertebral column than it does to any of the Caprimulgi. But it must be remembered that it is really very difficult to discern any truly striking resemblances among the vertebral columns of the several birds under consideration.

Turning to the *pelves*, we find on comparing the pelvis of *Trogon* with that bone as we find it in some of the Nightjars and Whip-poor-wills, that there is a certain superficial likeness which strikes us; but when we descend to the comparison of details, we are again met by the fact that these resemblances are purely superficial. Of course neither the pelvis of *Chordeiles* nor *Trogon* reminds us in the least of the unique pelvis which so conspicuously characterizes the skeleton of *Geococcyx*. How they would compare with certain other Cuckoo-like birds I am unable at present to say, from lack of proper material on which to form an opinion.

Passing to the *sternum* (and I have figured this bone for both *Chordeiles* and *Geococcyx* in my memoirs above referred to, and for *Trogon* in the present paper), we are at once struck by the resemblance between the sterna of *Trogon* and *Geococcyx*; the bones here are really very much alike, and both are essentially different from the single-notched sternum of *Chordeiles*.

Coming next to the *shoulder-girdles*, we are once more at sea, for these parts not only have no special likeness to each other, so far as *Trogon* and the Caprimulgi are concerned, but both, on the other hand, are extremely unlike the pectoral girdle as we find it in *Geococcyx*.

These remarks apply with equal truth and force to the *pectoral* and *pelvic limbs* of the several forms under examination; and even in the case of the reversion of the toes in *Trogon* and the Ground-Cuckoo, we are all aware that in the former bird the second toe is turned back, while in the latter it is the fourth one that is reversed.

I agree entirely with Professor W. K. Parker when he states that "the familiar term 'zygodactyle' for birds with a certain form of foot has been very useful; and yet how much ignorance it may be made to hide! It seems to be something when one knows that a certain bird belongs to that group; and yet a Cuckoo, a Parrot, and a Woodpecker come none the nearer each other zoologically by the possession of that kind of foot"*.

To recapitulate then, and judging from the *skeletons alone*, we must see that such a form as *Geococcyx californianus* is more or less remotely related to such birds as *Alcedo* and *Dacelo*, perhaps much nearer them than it is to the true Tree-Cuckoos. In saying this I am aware that in a paper recently read for me before the Zoological Society I was still inclined to support the classification of Garrod, who divided the *Cuculidæ* into two subfamilies, viz. the Ground-Cuckoos (*Centropodinæ*) and the true Cuckoos (*Cuculinæ*) (P. Z. S. 1874, p. 121); and this paper of mine referred to the anatomy of *G. californianus*, but at the time I had no specimens of true Cuckoos to compare it with. Still I am inclined to adhere to that opinion until I have had an opportunity of making further researches into the structure of many other types more or less nearly related. On the face of it I should be disposed to think that *Geococcyx*, so far as its skeleton is concerned, came nearer to such a form as *Dacelo gigantea* than to *Cuculus canorus*, for instance, notwithstanding the structure of the foot. But many of these interrelated groups are exceedingly puzzling, and still require a considerable amount of original investigation of their morphology.

Of the Caprimulgi, of course, I shall have more to say further on; it is very evident, so far as their osteology indicates, that they are very widely separated from the Trogons.

And now as to the Trogons themselves, still being guided by the skeleton alone, it is very plain that they have no special affinity with the Trochili.

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* Parker, W. K., "On the Morphology of the Skull in the Woodpeckers and Wrynecks," Trans. Linn. Soc., Zool. 2nd ser. vol. i. pp. 1–22.

When my eyes first fell upon the skeleton of one of these Trogons, as I have already stated, the remark was forced from me that they were "Caprimulgine Cuckoos." First impressions, however, are not always to be relied upon, for, apart from the general likenesses of their sterna, and having the same number of cervical vertebræ without ribs, from skull to pygostyle, and from pinion to pes, so far as the skeleton goes, *Trogon mexicanus* has nothing whatever to do with *Geococcyx californianus*, and, as stated, I have no true Cuckoos to compare it with. I dare say that if related to the Cuckoos at all, it is more than likely to be nearer these latter in its osteology. I have not had the opportunity, as yet, to examine the skeletons of either *Crotophaga* or *Scythrops*.

Beyond a few apparent resemblances I find nothing in the skeleton of the Trogons that in any way points to their being related, even remotely, to the order Caprimulgi; and it seems to me that there must be a considerable gap between the Trogons and Kingfishers.

THE ANATOMY OF CERTAIN CAPRIMULGI.

Glancing at our list of material, we find that we have but a few American forms to illustrate the structure of this highly varied group of birds. There is an alcoholic specimen of the common Whip-poor-will, a couple of skeletons of the Nuttall Poor-will, and several species of *Chordeiles*, both in alcohol and skeletons.

In my first contribution in the P. Z. S., relative to the structure of the Caprimulgine types, I gave a very full account of the osteology of *Chordeiles*, with a number of figures, as well as a description of the skeleton of Nuttall's Poor-will. I am convinced that when the hundred or more species composing this order come to be carefully examined as regards their structure, there will be not only some very good characters brought to light, but considerable difference found in the economy of the forms composing the group.

Among the notable departures it will be remembered that in my first contribution to their structure I found the arrangement of the bones of the palate entirely different in the Nightjars and true Whip-poor-wills.

As the external characters of these commoner American forms are well known, and are fully set forth in general works upon ornithology, I need not introduce them here.

Suffice it to say that these characters fully rank as *ordinal* ones in so far as they distinguish these birds from either the Swifts or the Humming-birds.

When I say ordinal ones I mean as pertaining to an order in the sense which that division holds as applied to Avian taxonony, and not to other vertebrate classes, where, as we know, structural differences are far greater than are to be found even among the extremes in the class *Aves*.

Having gone carefully over all the literature and material now available that bears in any way upon the present group, I find no reason to change my opinion as originally set forth in my memoir published in the Proc. Zool. Soc. 1885, where I proposed (p. 914) that all the Caprimulgine birds should be considered as constituting an order—the order CAPRIMULGI. I mentioned a number of the more doubtful forms that should be admitted to this order, as *Nyctibius*, *Steatornis*, *Podargus*, and others. Scarcely a doubt exists now, I think, in regard to the relation these birds bear to the Owls, through *Steatornis*, and, further, they have no particular affinity either with the Humming-birds nor the Swifts.

Their morphology is full of interest, and will repay very careful research in the future.

In the present connection it is my intention to lead off with a full description, if the one fine specimen in my possession will admit of it, of the anatomy of our common American Whip-poor-will (*Antrostomus vociferus*), making it comparative with the more aberrant genus *Chordeiles*, and then add something further in regard to the skeleton of *Phalænoptilus Nuttalli.*

On the Pterylographical tracts of Antrostomus *and* Chordeiles (*omitting the remiges and rectrices*).

Having carefully plucked my specimen of *Antrostomus vociferus* and one of *Chordeiles texensis*, and opened before me my copy of Sclater's edition of Nitzsch's 'Pterylography' at the proper page and plate (p. 87, pl. iv. figs. 1 & 2), I am prepared to present a few remarks upon the pterylosis of the Caprimulgine birds in my hands.

Commencing with the pterylosis of the head, I find in *A. vociferus* the same character which Nitzsch points out for the European Whip-poor-will (see Pl. XVIII. figs. 9 and 10 of this paper), and that is, on its superior aspect there is a triangular patch filling in the space just posterior to the superior mandible. Behind this the feathers form a median longitudinal tract of some width, which, extending down the back of the neck, as the dorso-cervical tract, forks between the shoulder-blades. Between this median tract on the top of the head and within the superior eyelid, on either side, we find a double longitudinal tract of contour feathers which join those in front, and posteriorly unite with the pterylosis of the inferior aspect of the head or the throat. Apteria occupy the interspaces among these supracapital, longitudinal pterylæ on the head of this Whip-poor-will, and as a distinctive feature it is even better marked in our specimen of *Chordeiles*.

It will be remembered that Nitzsch figured this character for *Caprimulgus europæus* and *Nyctornis grandis*, while he states in the text that he compared these two forms with *C. longipennis*, *C. forcipatus*, and *C. psalurus*. He also examined pterygraphically *Ægotheles Novæ-Hollandiæ*, *Podargus gigas*, and *Nyctornis æthereus*.

On the throat of the Common American Whip-poor-will the feathers are arranged in fairly well-defined, longitudinal rows, and Nitzsch found this to be characteristic also of the European bird; but in *Chordeiles* these rows are not very easily made out, if the throat-feathers are inserted upon any definite arrangement, and I am inclined to believe that in this latter form this is not the case.

Anteriorly the cervical region is densely feathered in both *Antrostomus* and *Chordeiles*, the tract extending to the points opposite the clavicular heads of the *os furcula*, laterally; while mesially an aptera occurs of no great extent between the forks of the bone just alluded to (fig. 9).

Nitzsch found a different state of things in this region in the European Nightjar, for he draws the entire antero-cervical space without feathers, which reduces the neck-tracts to two longitudinal, *lateral* pterylæ*, as shown in his figure of that bird.

The superior mandibular bristles in the Whip-poor-will before me are conspicuously long, and are deeply inserted as a single row just within the margin of the gape. These bristles gradually increase in length from before backwards, the posterior one being nearly 4 centimetres long. A few short and straggling ones are also found in the gular space beneath. In the Nightjar these bristles are very short, both above and below, and are by no means a striking feature in this bird, as they certainly are in the *Antrostomus*.

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* "Feather-tracts," from πτερόν and ὕλη.

Returning to the dorso-spinal tract in the last-named specimen, we find the extremities of the forks between the shoulder-blades, already alluded to above, joined by the ends of a similar but counter-disposed fork, coming, as it were, up from the lumbar region. From the apex of this latter the spinal tract appears to be more or less distinctly divided into two parallel rows, the median space between them being filled in with less regularly arranged feathers. Posteriorly the oil-gland stands between these rows, which slightly diverge as they reach it. This course of the spinal tract evidently creates a lozenge-shaped pteryla between the shoulder-blades, and this is even better marked in *Chordeiles*. The apteria or "featherless spaces" on the dorsal aspect of these birds are very sparsely covered with feathers to the extent shown in figure 10.

Now Nitzsch found quite a different arrangement of the spinal tract from this in the European Nightjar, as may be seen from his figure, and the words of his text, where he says, "spinal tract at first broad, forked between the shoulder-blades, each branch united to the broad rump-band by a single row of contour-feathers."

We must, however, recollect that this eminent naturalist also stated that these tracts differed "in the various genera."

A curious departure is seen in *Chordeiles texensis*, where, on either side, a broad tract joins the hinder apex of the lozenge-shaped dilatation of the spinal tract with the posterior extremity of the ventral band of the corresponding side. The course of this broad connecting band is directly beneath the "armpit."

Speaking of the "oil-gland" in these birds, Nitzsch says it "is remarkably small, probably the smallest in proportion that occurs in the whole class of birds; it is of an elongated oval form, without a circlet of feathers at the tips" (*op. cit.* p. 87). This description applies in every particular to the two American forms of Caprimulgi before me.

As shown in Pl. XVIII. fig. 10, the "femoral tracts" are very definitely marked in *Antrostomus*; they are broader and more diffuse in *Chordeiles*. The feathering of the integuments of the pelvic limbs of either of these genera is somewhat sparse and scattered, and without definite pattern.

Turning now to the ventral aspect of the body, we find, in common with what Nitzsch found in *Caprimulgus*, that in these American forms the anconal surface of the wings are very thickly feathered all over; the feathering becomes scattered as we pass on to the patagium; but the free anterior edge of this latter membrane has a narrow and dense row of small feathers inserted along its entire length.

I have already described above the pterylosis of the anterior cervical region; this leaves us to consider the feathering of the pectoral aspect of the body. Here we find that both *Antrostomus* and *Chordeiles* agree very closely with the European Nightjar, as the pterylosis of that bird has been described by Nitzsch.

The ventral tracts in all are broad, broader than the well-defined humeral tracts of the dorsal aspect, being rather widely separated in front, and blending somewhat with the aforesaid humeral tracts at the summit of either shoulder.

The median apterium of the chest (if we may apply this term to it here) is uniformly, though thinly, feathered in both *Antrostomus* and *Chordeiles*, which sparse feathering is extended over the abdomen below. This condition is not taken into consideration by Nitzsch in his figure of these parts in *Caprimulgus*. From the posterior extremity of the broad ventral tract on either side in the Whip-poor-will and Nightjar we find a narrow contour abdominal tract running backwards on a curved line to join the fellow tract of the opposite side behind the vent.

The pelvic limbs are fairly well covered with feathers upon this aspect, though not so much so as they are upon the reverse sides.

So much, then, for the pterylography of the Caprimulgine birds now under consideration. After the detailed way in which I have attempted to describe it in the above paragraphs, it will be hardly necessary to present synoptical tables of differences or similarities to be found in the two American genera examined. The principal facts to bear in mind are that the pterylosis of the American *Antrostomus vociferus* differs from the pterylosis of the European bird as described by Nitzsch in a few well-marked particulars, and that both of these forms again differ in this particular from *Chordeiles*, to say nothing of the further departures which we find when we come to compare both Whip-poor-wills and Nightjars with such types as *Nyctornis grandis* and some others.

No doubt further on we shall find that still more striking differences in pterylosis exist among the Caprimulgi and the Swifts and Humming-birds, to say nothing of what may be discovered between the last two groups in this regard.

Before concluding what I have to say about this character in the Caprimulgi, it should be observed that although they differ among themselves in their pterylography, there is a certain general similarity of pattern in them all, the fundamental characters of which are probably well exemplified in our *Antrostomus*, as shown in figs. 9 and 10; while the departures from it may be easily made clear and apparent by the most superficial comparison of the several genera, as I have attempted to point them out or directed attention to those already described by Nitzsch.

Observations on the Anatomy of Antrostomus *apart from the Skeleton.*

(*Comparisons with* Chordeiles.)

Thanks to the labours of Huxley, Müller, Nitzsch, Macgillivray, Cuvier, Garrod, and Forbes, and to an admirable paper by Mr. Frank E. Beddard, the present Prosector to the Zoological Society of London (P. Z. S. 1886, p. 147), much is already known of the anatomy of the most prominent representatives of the order Caprimulgi.

In the present connection I shall attempt little more than a verification of the observations of these trustworthy writers by dissections of the material I have at hand, and thus fill in the scheme of my memoir.

First, then, in the two specimens before me, with a scalpel I carefully remove the integument entirely from the head and down as far as the root of the neck. This done, the first thing that strikes us is that we can easily discern the form of the superior aspect of the brain even through the skull-walls, which have here been rendered more or less transparent by soaking in alcohol. It will be observed that the brain of *Chordeiles* is considerably larger than the brain of the Whip-poor-will, notwithstanding the fact that in the latter bird the skull is markedly wider, longer, and flatter; while in the Nighthawk the parietal region of the skull is more dome-like and rounded. The eyes in the Nighthawk are rather larger than they are in the Whip-poor-will; while in the latter the recurved limbs of the hyoidean cornua are longer, more median, and reach higher up on the cranium than they do in *Chordeiles*.

Marked differences of course characterize the skulls of these two forms; but of this we shall have something to say later: the inter-ramal layer of muscles is thicker in *Chordeiles* than it is in *Antrostomus*, completely shutting out of sight the hyoidean apparatus in the former bird, while its form can be easily made out in the last-named type through this muscular layer.

We need not enter here upon a comparison of the structure of the neck in these two birds, but proceed at once to remove the skin from the body and limbs.

On the Mode of Insertion of the Patagial Muscles of the Pectoral Limb.

These I not only examined in the specimens before me of *Antrostomus* and *Chordeiles texensis*, but in a number of other species of the latter genus, with the following results. Our American Whip-poor-will, I find, has the tendons of these patagial muscles of the arm inserted in precisely the same manner as Garrod found them in *Caprimulgus europæus*, see either in his "Collected Memoirs," or in my copy of his figure in my "Contributions to the Anatomy of *Geococcyx*" (P. Z. S. 1886, p. 471). But it will be as well to mention here that these tendons are far more slender than one would be led to suppose from this anatomist's drawing alone. They are exceedingly delicate in structure. This remark, however, does not so well apply to these tendons of the patagial muscles as we find them in the genus *Chordeiles*; here they are decidedly broader and stronger than they are in the Whip-poor-will, and also present certain well-marked differences. Now, although the plan of arrangement is essentially the same in the Nighthawks, we find that the tendon (the main tendon) of the tensor patagii brevis is evidently composed of two longitudinal slips coming off from the distal apex of the muscle together, they being but lightly held together, as they descend towards the muscles of the forearm, by a delicate connective tissue. The anterior or distal division of this double tendon is the one which becomes inserted in the *extensor metacarpi radialis longior* muscle of the forearm at the juncture of its tendon and fleshy part. The inner slip of the main tendon of the tensor patagii brevis, or the slip next to the humerus, is directed as in the Caprimulgi generally. In other words, the arrangement here is the same, only the tendon of the muscle makes it appear somewhat different from the arrangement in the Whip-poor-will, upon dissection, from the fact that in the main tendon the two slips are so evidently distinct. Both of these birds possess the "bicipital slip," shown by Garrod to be present in the Caprimulgi.

There is yet another point, however, present in the Nighthawks which I have failed to find in the specimen of *Antrostomus* before me. It is this: when the tendon of the *tensor patagii longus* muscle comes to be about opposite the points where the slips of the tendon of the *tensor patagii brevis* are inserted into the structures of the forearm, it sends off a delicate little tendinous slip which is inserted upon the *extensor metacarpi radialis longior* muscle, at the same point where the distal slip of the tendon of the last-named muscle is also inserted, *i. e.* at the point of union of its tendon and corneous portion.

On reading over this short description as detailed in the last few paragraphs, it seems hardly necessary to give any figures to make my remarks the clearer; it will be well to note, however, that among the North-American Caprimulgi at least—and it will undoubtedly hold good for the entire group,—the method of insertion of the slips of the tendons of these patagial muscles of the arm may differ for the several genera very appreciably, and on proceeding with my dissections of *Antrostomus* and *Chordeiles* I am the more convinced that, *as genera*, they are very well-marked ones.

Of the Pectoral Muscles.

Both in *Antrostomus* and *Chordeiles* all three of the pectoral muscles are present. *Pectoralis major* and *pectoralis secundus* are in each case very well developed, while *pectoralis tertius* is quite small and insignificant in comparison even with the second pectoral. It arises mainly from the shaft of the corresponding coracoid, and only the extremities of its most posterior-reaching fibres arise from the sternum, and not as in many other birds, where a proportionately good share of its bulk may spring from this last-named bone.

All these pectoral muscles are inserted into the humerus in a manner common to the great majority of the class Aves, and require here no special remarks upon that point.

Notes on the Anatomy of the Pelvic Limb.

When examining that group of muscles of the thigh used so successfully by him in classification, Garrod dissected specimens of *Caprimulgus europæus* and *Chordeiles texensis,* almost identically the same forms as those before us. In them he found that they possessed the "femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ;" but "the ambiens and the accessory femoro-caudal are absent." (Coll. Mem. p. 192.)

My observations tend to confirm these results for the genus *Chordeiles,* and enable me to say that the same statement holds good for *Antrostomus*; both limbs of the birds before me were carefully examined, and all the muscles of the thigh dissected out. I also saw that the main artery of the limb was the *sciatic,* as it is in the majority of birds.

Passing next to the foot, I dissected out the *plantar tendons* of both feet in the Whip-poor-will, and the same parts in both feet of *Chordeiles texensis* and *C. texensis,* var *Henryi.*

Here again I can confirm the observations of Professor Garrod, who found that in *Caprimulgus europæus* "the two deep flexors descend beyond the ankle-joint independently, as usual; after passing which, generally about one third down the tarso-metatarse, they blend completely *before* any slip has been given off. From the conjoined tendon thus formed, the tendons of distribution spring, four in number, one to the hallux and others to each of the three anteriorly directed toes (see Collected Memoirs, fig. 4, p. 292), that to the hallux being generally separated off before any of the others." (*Op. cit.* p. 294.)

It struck me, however, that in *Chordeiles* the tendon of the *flexor longus hallucis* enjoyed a greater degree of freedom than had been found by the anatomist just quoted to exist in *Buceros rhinoceros*, which I believe to be as he found it in *Caprimulgus*; as in *Chordeiles*, it is easily separable from the deep flexor *along its side*, thus approaching somewhat more nearly the condition as found in *Momotus lessoni*.

Other Notes.

Cuvier, Nitzsch, and Beddard (P. Z. S. 1886, p. 147) have all made careful examinations of the syringes of the *Caprimulgi*; and the tracheo-bronchial syringes of *Caprimulgus* and *Chordeiles* are well known. I have investigated this part of the anatomy of the forms before me, and find they agree in all particulars with the descriptions given by the above authorities; all of which will obviate the necessity of my entering upon further details here. Beddard's paper, just alluded to, is a real contribution to the anatomy of these parts for the Caprimulgi, and will well repay reading in the present connection.

Antrostomus has two carotids present, taking the usual course up the neck in the mid-vertebral canal. This agrees with what is already known for *Caprimulgus* and *Chordeiles*; and I verified the fact in the latter bird in the specimen at hand.

Intestinal cæca are present in both *Antrostomus* and *Chordeiles*, being in each case a long slender pair (fully 4 centimetres in length), and each about one half the calibre of the intestine to which they are attached.

Upon investigation I find that *Antrostomus* possesses a small gall-bladder, while the several species of *Chordeiles* lack this organ: this confirms the observations of Mr. Beddard, who found that in the latter case Garrod had also left a MS. note to that effect (P. Z. S. 1886, p. 151).

The form of the œsophagus and stomach is pretty much the same in both the Whip-poor-will and Nighthawk, although as regards size it is comparatively larger in the latter bird. I find it to be a flask-shaped pouch, somewhat compressed from side to side, with the walls of a fairly uniform thickness, and composed of strong rugæ. These, commencing at the lateral tendinous centres at either side, curl round and round in double loop until they come to the œsophageal tube, which they ascend for a short distance and upon which they are gradually lost. These rugæ are so well marked that they may be easily discerned from an examination of the external surface of the stomach; and upon the dorsal aspect of the organ they seem to rise into a sort of transverse ripple, a character present also in the Whip-poor-will. The œsophagus is of large calibre in these birds, and, as stated, thick and firm as it approaches the gastric pouch.

The small intestine is delicately constructed, and not especially large as it passes from the wall of the stomach at a point situated at the upper right side of the organ, not far from where the œsophageal tube enters.

Inside the stomach the gastric rugæ are covered by a moderate layer of corneous tissue, composing about one third the thickness of the stomach-wall, which may best be seen upon a section of the organ.

Of the Osteology.

For the purposes of classification I gave in my first memoir on the present subject (P. Z. S. 1885) sufficiently full descriptions of the skeleton in specimens of *Chordeiles* and *Phalænoptilus Nuttalli* for all that is required in the present connection; so it will be only necessary here to make some additional remarks upon the skeleton as found in my specimen of *Antrostomus*. Judging from the figure of the base of the skull of the common European Nightjar, which I copied from Huxley and reproduced in my first memoir, I should say that, osteologically, the American form of this bird was very much like it in that particular system of its anatomy: indeed, I expect that structurally the two forms are very similar. Then, as one would naturally have expected, I have found, upon a mere superficial comparison, that osteologically the common Whip-poor-will and Nuttall's Poor-will (*P. Nuttalli*) are very much more alike than either of them resemble *Chordeiles*. In fact, it takes but a glance at a skeleton of a true Whip-poor-will and a Nighthawk to convince us at once of the marked differences that exist between them. As I have elsewhere said, these two genera of Caprimulgine birds are separated structurally by very excellent characters of a nature at once recognizable.

Figures in the plates of my first memoir, above alluded to, also illustrated the skull of a *Chordeiles* and the principal bones of its skeleton; and for further description these will answer all the purposes required. In the present paper, however, I have thought it best, for the sake of completeness, to add three figures of the skull of Nuttall's Poor-will (*P. Nuttalli*) in order to show how well it agrees with *Caprimulgus* and *Antrostomus*, and differs from the skull in *Chordeiles* given in my former memoir (Pl. LIX. figs. 1, 2, and 4).

Upon more careful and extended examination, I find that, except in point of size, *Phalænoptilus* being about one third less than *Antrostomus*, the skulls, mandibles, and hyoidean apparatuses of these two forms are very much alike indeed, in all essential particulars. And as the characters of the skull of the Whip-poor-will are well known, and, further, as I present herewith figures in the Plate of the skull of the Poor-will, I believe that any further comments upon this part of the subject would be superfluous.

One point, however, in respect to the hyoid. In my former paper I made the statement that in it the basibranchials in Nuttall's Nightjar were in two pieces. This was true for the specimen examined, although in the skeleton of *Antrostomus* before me these parts are anchylosed together, which may be the case in all old birds of both these genera. *Chordeiles* has them in one piece; and I am led to believe from this that it will be found to be generally the case in our N.-American Nightjars.

Passing next to the remainder of the axial skeleton in *Antrostomus*, I find my account of the corresponding parts for *Chordeiles* and *Phalænoptilus Nuttalli* (P. Z. S. 1885, p. 903) to be so complete that it leaves but little here to be added.

Upon carefully re-comparing the axial skeletons of the three genera *Chordeiles, Phalænoptilus*, and *Antrostomus*, now in my hands, it confirms my previous notions as to their agreements and disagreements; and, as one would naturally expect, the skeletons in the two Whip-poor-wills, or rather the Whip-poor-will and Nuttall's Poor-will, are most alike.

The skeleton in a specimen of a Nightjar has already been described in the place just alluded to; and now I find that *Antrostomus* agrees with *Phalænoptilus* in having *eleven* vertebræ in the cervical division of its spine before we come to that which is the first in the column to have free ribs attached to it. These ribs in the Poor-will, however, are described as being rather long;

whereas in the specimen of the Whip-poor-will before me they are quite rudimentary and small, although they have both head and tubercle.

For the rest of the vertebral column in these two birds, they practically agree, both in number and arrangement of the ribs and vertebræ. Their *pelves* are also very much alike, and wear the same pattern for general outline, even to the pointed and in-turned anterior tips of the ilia, which latter feature constitutes a very excellent character for this bone, at once distinguishing it from the pelvis of a *Chordeiles.*

Antrostomus also agrees with the Poor-will in having but *five* free vertebræ and a pygostyle in the skeleton of its tail; whereas it will be remembered that the several species of *Chordeiles*, as a general rule, have *six* and a pygostyle. I have yet to find an exception to this statement. All three genera seem to possess *ten* vertebræ in the series that anchylose together in the pelvis.

In *Antrostomus* in the dorsal series of vertebræ, as in all the Whip-poor-wills and Nightjars which I have examined, the hæmal spines are comparatively long and conspicuous, the anterior ones being trifurcate at their extremities.

Essentially the form of the *sternum* in *Antrostomus* agrees with the same bone in *Phalænoptilus*, and the general form it assumes for the true Caprimulgine birds is very well shown in the figure I gave of the sternum of *Chordeiles texensis* in plate lxi. of my first memoir, which can be referred to in the present connection. With three specimens of this bone before us, one being chosen from each of the three genera in question, they may be in general distinguished by the following characters :—The sternum of *Chordeiles* is the largest of the three, and that of *Phalænoptilus* the smallest. The "costal processes" in the Whip-poor-wills are simple erect spines (best marked in *Antrostomus*)· whereas in the Nightjar they are more like laterally-compressed plates, and as we find them in many other birds. All three have the pair of deep rounded notches in the posterior end of the body of the bone. They are all without manubrial processes.

The *shoulder-girdle* in *Antrostomus* is very like those parts as I have already described them for Nuttall's Poor-will, being only proportionately larger.

Turning, now, to the *pectoral* and *pelvic limbs* in this American Whip-poor-will, we find that they also essentially agree, except in point of size, with the corresponding bones and parts in *Phalænoptilus Nuttalli*, those in *Antrostomus* of course being the larger.

With a skeleton of the latter bird now before me, and carefully reading over my descriptions of the limbs of *Chordeiles* and *Phalænoptilus*, as I gave them in my first memoir on this group, I find that there is nothing special to add to that account; all the essential characters of these parts being duly presented for the American forms of Whip-poor-wills and Nightjars.

There is one more statement I made there that seems, however, to demand correction; for in describing the proximal phalanx of the index digit of the manus I said of its expanded portion in *Phalænoptilus*, that of the two perforations which were found in it in *Chordeiles*, they merged in the former bird "into one large one." This is not so; for upon a more extended examination I find that there are always *two* perforations in this part of the bone in *all* the forms we have been considering.

This is all I have to state in regard to the descriptive part of the structure of the Caprimulgine birds of the United States. Should it become necessary further on to fall back upon this descriptive part, for the sake of comparison with the remaining groups yet to be described, it will be done; but, so far as I am concerned, I am firmly convinced that, taken as a group, including all other Whip-poor-wills and Nightjars, and such forms as *Nyctibius*, *Psalurus*, *Steatornis*, and *Podargus* and others, they are fully entitled to rank as an Order of birds, which I have elsewhere designated as the CAPRIMULGI.

Not having personally examined such forms as *Podargus*, *Ægotheles*, *Nyctidromus* *, *Batrachostomus*, and others, I am not fully prepared to offer an opinion as to the families and other divisions of such an Order, nor to state definitely to which other groups the Caprimulgi are most nearly related; but I can hardly agree with Prof. Huxley, who asserts that "the Caprimulgidæ come near *Trogon*, and more remotely approach *Podargus* and the Owls" (P. Z. S. 1867); for believing, as I do, that *Podargus* belongs to the Order, I am also inclined to the opinion that we shall find that, through *Steatornis* and *Podargus*, the Caprimulgi are nearer the Owls, and only remotely approach the Trogons.

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* I have since examined skeletons of *Nyctidromus albicollis*, var. *Merrilli* sent me by my collectors in Texas.—R. W S.

Again, I can hardly agree with Mr. Beddard *, who would retain such forms as *Antrostomus* and *Chordeiles* in the same "subfamily;" for surely all the essential structural characters of these two forms are of *family* and not *subfamily* rank: a comparison of the skulls alone is almost sufficient to determine this point. And the breach between *Chordeiles* and *Steatornis* must indeed be wider than a mere subfamily line can indicate.

ANATOMY OF THE NORTH-AMERICAN HIRUNDINIDÆ.

From my list of material at the beginning of this memoir it will be seen that I have at hand specimens of every genus and species of Swallow at present entitled to a place in the United-States avifauna, and a sufficient series of each to enable me to fully investigate their structure.

I will take them up, species by species, in the order in which they occur in the 'Check-List' of the American Ornithologists' Union, but need not present a synoptical table of their external characters, for these are well known to ornithologists and ornithotomists the world over.

To commence with them, then, we will take a look at the pterylosis of a specimen of *Progne subis*, compare it with the figures given in my Plate of *Ampelis cedrorum*, and with Nitzsch's drawing of the pterylosis of *Hirundo urbica* in his 'Pterylography,' and next with other American *Hirundinidæ*.

Now it will be remembered that we found the pterylosis of *Ampelis* to agree essentially with most true Passeres, wherein, upon the dorsal aspect of the body, the chief feature is that the "spinal tract" terminates in a lozenge-shaped pteryla situate mesially between the thighs; and on the ventral aspect we have another well-known distribution of the pterylæ characteristic of most Passerine birds. *Progne* differs from all this, and agrees in the main with *Hirundo urbica* as figured by Nitzsch.

This author, however, does not present in his work a ventral view of the pterylosis of a Swallow, but says in his text that "the single genus *Hirundo*, which constitutes this group [*Hirundines*], differs more than any other in its habitus from the general type of the Singing-birds, and in this respect approaches very closely to some *Cuculinæ*, namely the Cypseli. For this reason I usually place it at the end of the Passerinæ, in the vicinity of the anomalous cuculine form just mentioned, which stands in the same relation to the true Cuckoos as the Swallows to the ordinary Song-birds. However, pterylographically, *Hirundo* does not differ from the rest, but rather harmonizes completely with *Dicæum*, in that the rows of single contour-feathers uniting the saddle with the rump-band are either entirely deficient (*H. rustica*, *H. urbica*) or indicated only by two rows of very sparse contour-feathers (*H. rupestris*). The dilatation of the pectoral part of the inferior tract is somewhat divergent at the end. The number of remiges is eighteen, of which nine are on the hand, and of these the first is the longest; the first six secondaries are remarkable on account of their broad, emarginate extremities" (pp. 84, 85, 'Pterylography').

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* P. Z. S. 1886, p. 153.

Now, in *Progne* I note that the "saddle" at the end of the spinal tract is very broad, although forked as in *Hirundo urbica*, but the posterior extremities of the limbs of this bifurcation are joined, on either side, to the anterior end of the rump-tract by distinct and well-marked rows of contour-feathers. Further, the bifurcation of the "saddle" takes place at about the middle of the back, and not nearly so low down, namely between the thighs, as in *Hirundo*. Another point to note upon this dorsal aspect in *Progne* is that the "alar tracts" are very extensively joined with the anterior endings of the "humeral tracts." In *Hirundo* Nitzsch even seems to leave an unfeathered space, on either side, in these localities. The "capital area" is the same, but in *Progne* there are no naked areas around the eye and auricular orifice, as in *Cypselus*, and as Nitzsch has also drawn them for *H. urbica*.

Under the throat in *Progne* and in most Swallows we find a longitudinal naked strip running down close to and just within the ramus of the mandible, on either side, which terminates at about the angle of the jaw. It will be remembered that in the Whip-poor-wills and others this feature is also present, except in them it assumes a somewhat different type, the feathers of the throat being arranged in regular rows. I am inclined to believe that there is a reason for this, which is, that in these birds, accustomed as they are sometimes to swallow very large insects, an operation which must distend the throat, or even momentarily place the integument there on the stretch, these unfeathered strips would spread to meet the action, but as the parts came to rest again after swallowing, the feathered areas or strips would again become juxtaposed and the throat apparently full-feathered. In some Swallows (e. g. *Chelidon*) these naked strips are only brought fully into view by stretching the integument of the throat.

No special note is necessary to be taken of the ventral pterylosis of *Progne*, as it has all the essential characters of the pattern seen in a Passerine bird, and departs but slightly therefrom. It is more like *Cypselus*, however, than it is like such a form as *Ampelis*, for instance, in that the ventral tract, on either side, overlying the pectoral region, does not show that heavy feathering to its external margin as seen in the latter type. In Swallows, as in all Passerine birds, the oil-gland is nude.

Now I have plucked, with the greatest possible care, an adult male specimen of every Swallow in our avifauna, and the birds are now before me.

In *Petrochelidon lunifrons* the "rump band" on the back is very wide, and is joined anteriorly on either side by a very distinct double line of feathers from the corresponding fork of the "saddle." The ventral bands of the pectoral region are broad but evenly feathered, while on this dorsal aspect the alar tracts meet and blend with the anterior ends of the "humeral tracts." This last feature is invariably the case with all our Swallows, and is best marked in *Clivicola* and *Stelgidopteryx*.

In other particulars *Petrochelidon* essentially agrees with *Progne* in its pterylosis, and with the *Hirundinidæ* generally.

Chelidon likewise has the posterior ends of the saddle-pteryla of the dorsum joined by feather-rows, one on either side, with the rump-band, which latter here is narrow again and strictly defined. Neither this Swallow nor *Petrochelidon* have naked annular areas around their eyes, nor the orifices to their ears. In fact, none of these Swallows possess this last feature. Otherwise, the pterylosis of *Chelidon* is characteristically hirundine.

Neither *Tachycineta bicolor* nor *T. thalassina* have the bifurcations of the "saddle-pteryla" of the dorsum joined with the "rump-band," as in the foregoing forms, but the ventral tracts are here again broad and evenly feathered.

In view, then, of the fact that the pterylosis of the *Hirundinidæ* is pretty well known, it will not be necessary for me to enlarge further upon my account of it.

But the principal thing to be borne in mind in the present connection is, that Swallows, Swifts, and Humming-birds *all* depart from the more typical pattern of pterylosis found in true Passeres. And in the case of the Swallows and Swifts, so far as Nitzsch's figures and descriptions go, for I have not yet examined the Cypseli myself for this character, the pterylosis of the latter is of such a pattern that it requires but very little modification to make it agree with the pterylosis of a Swallow. Indeed, in those Swallows where the "saddle-pteryla" of the dorsum joins its bifurcations with the anterier end of the "rump-band," the pattern is nearly the same, differing principally in relation, width of the tracts, and position of the bifurcation of the saddle, which, in *Cypselus apus*, is between the shoulders.

On the Mode of Insertion of the Patagial Muscles in the Swallows.

Scarcely any difference is apparent among the various species of Swallows at hand in regard to the mode of insertion of this group of patagial muscles, now known to be of so important a character in the taxonomy of the class. I have carefully examined them in all the American species, and find that, so far as the *tensor patagii brevis* is concerned, both its origin and insertion seem to be almost typically Passerine. This observation applies with equal truth to the *tensor patagii longus*; and as these muscles are now so well known to all working morphologists, I need not redescribe them here; moreover, in figure 2 of Plate XVII., I have drawn them for *Ampelis*, which will recall their appearance for the *Passeres*.

During the course of my dissections upon this region in the *Hirundinidæ*, however, I came across, as I did in *Ampelis*, what I am inclined to believe is a hitherto undescribed muscle, at least so far as Garrod's descriptions go. It first came to my notice in a specimen of *Progne subis*, whereupon I at once dissected a number of other individuals of the same species, and found it equally well developed in all of them.

This muscle, in part, is a dermal muscle, and arises from the integuments on the anterior aspect of the neck at about its lower third; at its origin its fibres spread out fan-fashion, their terminal ends meeting those of the muscle of the opposite side in the median line. Here it is quite adherent to the skin, but its fibres rapidly converge as they pass in the direction of the shoulder-joint, opposite which region they gradually free themselves from the skin to form a small fusiform muscle, which, ending in a delicate tendon, runs along within the free marginal fold of the patagium of the wing, in common with the tendon of the *tensor patagii longus*, to blend with it just before reaching the carpal joint.

I propose to call this muscle the *dermo-tensor patagii*, it being partially connected with the integumentary system of muscles in the birds in which I have thus far found it.

Searching for it in all the other American Swallows, I find it to be about equally well developed in every species, and absent in none of them.

This muscle surely does not correspond with the "bicipital slip of the patagium," as described by Garrod, and dwelt upon as the *tensor patagii accessorius* by Professor T. Jeffery Parker in his 'Zootomy' (1884, p. 251) as occurring in the Common Pigeon, for it makes no connection whatever with the biceps muscle.

Being desirous at this point of determining its presence or absence in a few other groups of birds, I stepped aside for the moment, and first examined a number of Passerine types, including very diverse forms,—it was present in all of them. Next, with the Caprimulgi, Trochili, and Cypseli, I found it completely absent, as it was also in a specimen of *Tyrannus tyrannus*, kindly sent me by Mr. H. K. Coale of Chicago, from which I am led to infer that it does not occur in the mesomyodian Passeres. Further than this I did not pursue the subject, but left it for subsequent investigation and the researches of others interested in such matters *.

Of the Pectoral Muscles.

Every species of American Swallow has been dissected by me to ascertain the character and number of these important chest-muscles as they occur in the group. In every individual instance I found the state of affairs essentially the same, and the Swallows agree with all true Passerine birds which I have thus far examined, in possessing all three of the pectoral muscles. The *pectoralis tertius* is, comparatively speaking, very large, and arises nearly or quite as far back on the anterior aspect of the sternum as the *pectoralis secundus* does; it also arises, as is usual, from the outer side of the shaft of the coracoid bone of the shoulder-girdle. *Pectoralis major* makes a very broad and strong tendinous insertion at the ordinary site upon the shaft of the humerus, while the tendon of the second pectoral passes through the usual canal formed by the juxtaposition of the bones of the shoulder-girdle. In texture the fibres of the great pectoral in Swallows seem to be always coarse and of considerable size.

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* Further opportunities for examining the literature of this subject now enable me to state that the muscle here described is the "*pars propatagialis musculi cucullaris*" of Fürbringer and Gadow; and it has been carefully considered by me in an extensive work upon the muscles of birds now in the hands of the Smithsonian Institution for publication.—R. W. S.

To these characteristics with respect to the pectoral muscles as I found them in the smaller representatives of the group, *Progne subis* forms no exception.

Of the Muscles of the Thigh.

According to Garrod all Passerine birds exhibit, for the classificatory group of muscles of the thigh, the myological formula A. X. Y (except *Dicrurus*, wherein it is A. X); *i. e.*, they possess the femoro-caudal, the semitendinosus, and the accessory semitendinosus—the accessory femoro-caudal and ambiens being absent. Upon carefully examining the Swallows, I find that this is also the rule with them; and these muscles seem to be about equally well developed in the several genera, although it struck me that the accessory semitendinosus was, comparatively speaking, rather feebly developed in *Progne*. Beyond these special muscles, I did not investigate the myology of the pelvic limb of these birds.

Notes on the Arterial System.

Swallows, in common with other *Passeres*, also have but one carotid artery, the left, which courses up the neck, as usual, in the hypapophysial channel at the mid-anterior aspect of the cervical vertebræ. And in the pelvic limb the main artery I found to be the *sciatic*, which is likewise the rule among the Passerine birds, and Professor Garrod found but few exceptions to this.

On the Trachea, Visceral Anatomy, and other parts.

More for my own satisfaction than with the expectation of revealing any structure that would prove to be different from what we already know of the morphology of the trachea or other parts in the Passerine birds, I examined the wind-pipe, its muscular and associate parts, as I did the several organs in the chest and abdomen of these American Swallows, but found nothing that required to be specially noted here.

The trachea exists as we find it in most true Passeres, as do the several pairs of muscles at its lower larynx. I found the "sterno-tracheales" to be very delicately formed indeed, almost of hair-like proportions in some of the genera, as in *Progne.*

The gall-bladder is of good size, and the right lobe of the liver the larger division of that organ.

Cæca coli are present in Swallows, but are of almost rudimentary proportions, and in some cases might be easily overlooked.

It is my intention to refer to a few of these points again, when we come to consider the visceral anatomy of the Swifts and Humming-birds.

The Osteology of the Hirundinidæ.

Skeletons of representatives of all the *Hirundinidæ* of the United States are before me, and in sufficient number, so that a general definition for this part of the structure of these birds becomes quite possible, and will be given here. It is my intention, however, to be brief in this matter, not only on account of space, but in view of the information already given.

Of the Skull.—When I came to compare and examine the skulls of our seven species of Swallows, I was surprised to find them presenting such striking differences in their general form. Not but that they could each and every one of them be recognized at once as skulls of Swallows, but rather that they possess characters quite distinct and peculiar to the species, and there would be no difficulty whatever in telling, for instance, the skull of a Barn-Swallow from one of a Cliff-Swallow—so diverse is the general outline of each.

In *Progne subis* (Pl. XXI. figs. 18, 19, and 20) we find a skull that exemplifies all the characteristics which pertain to the Hirundine skull generally.

Its superior osseous mandible is very broad at the base, but promptly tapers to a sharp and somewhat depressed tip anteriorly, while all this portion of the skull is much compressed in the vertical direction. The form of the external narial apertures can best be appreciated upon a superior aspect, and are seen to be long, elliptical openings placed longitudinally. Through either one of them we may discern the upper surface of the anterior part of the palatine of the corresponding side. The lateral free edges of this mandible are sharp and turned downwards, while the maxillary on either side is a horizontal plate fully three times as broad as the slender jugal bar that continues this infraorbital rod to the quadrate. We find no projecting processes from the lateral margins of any part of this osseous superior mandible as have been erroneously figured for the skull of *Progne* by other anatomists ('Science,' N. Y., No. 223, fig. 3). Just anterior to the frontals, and posterior to the external narial apertures, there exists a subtriangular area of bone on the top of the mandible, which is formed by the proximal portion of the premaxillary and the nasal bone on either side. In the adult skull, of course, the *sutural* boundaries of these bones have been absorbed, but by holding the skull up to the light the proximal end of the premaxillary, and what was the median margin of a nasal, and finally the anterior limit of the corresponding frontal bone can all be easily distinguished, while the small triangular space they circumscribe, is also of bone, but considerably thinner than the other parts mentioned. In all Swifts that I have examined this thinner portion on either side has become absorbed, and a little triangular opening is found at the site instead. My explanation will be made quite clear by turning to Plate XXI., and comparing figures 22 and 23; in figure 23 at *x* is shown the thinned portion, while in the Swift's skull, figure 22, an opening actually takes its place on either side. Of course, in a skull so vastly different from the Cypseline skull as the Humming-bird's is, no such comparison as this is necessary.

For the rest of the superior aspect of the skull in *Progne* we find the frontal region narrow between the orbital margins, the posterior edges of which latter are sharp, thin, and somewhat tilted upwards. The parietal region is smooth and rounded, while a shallow, mid-longitudinal gutter traverses this part of the skull (fig. 19).

Regarding this part of the skeleton of the Purple Martin upon a lateral aspect (fig. 18), we are to note the form and comparatively large size of the pars plana (*p.p.*), the slender and rather small pterygoids, as well as the fact that the osseous interorbital septum is pierced by two large vacuities of a form in most specimens shown in the drawing. This figure displays so well the characteristics of the lateral part of the cranium proper in *Progne*, that any further account becomes superfluous.

Turning to the base of this skull (fig. 20), we are to note the form of the vomer and the maxillo-palatines; the first has very much the character of that bone as we usually find it in the Passeres. The maxillo-palatines have their median free extremities dilated, and they, as in all Swallows, are separated by several millimetres in the middle line.

The palatines articulate with each other for the posterior two thirds of their length beneath the sphenoidal rostrum, and are in close contact at their pterygoidal heads, as in the pterygoids themselves in this latter locality.

As in all Cypseline birds which I have examined, the posterior external angles of the palatines in *Progne* are somewhat drawn out, and then squarely truncated (compare figs. 19 and 22, *pl*). Swallows have the occipital condyle very small, while the foramen magnum is relatively large, and its plane makes an angle with the basi-cranial plane of some eight or ten degrees.

Posteriorly, the skull in *Progne* exhibits a large supra-occipital eminence, and an occipital area which is nearly circumscribed by a sharply defined occipital ridge or line, which defines its form as reniform, and placed transversely at this aspect of the cranium.

Coming next to the *mandible* of this bird, we find it to be of a V-shaped outline, with its ramal sides shallow in the vertical direction, and with a symphysis of some depth anteriorly at its apex. There is a swell, on either side, at the superior ramal margins at points about where the horny theca ceases and the skin commences, when these latter parts are *in situ*. A small slit-like ramal vacuity exists, and the posterior angular processes are well-developed, though they curve up but very slightly.

Essentially, the hyoidean apparatus is Passerine in character;

I find, however, that the basibranchials are anchylosed into one piece, while the glosso-hyal and the cerato-hyals are apparently not ossified even in the adult Martin.

Several skeletons of *Petrochelidon lunifrons* have been carefully prepared by me from specimens of the bird which I collected a year ago at Fort Wingate, New Mexico, and they are now at hand. So far as the skull and hyoidean apparatus of this Swallow are concerned, we might almost cover the ground of our description by saying that in these parts the bird is the veriest miniature of *Progne*; and, indeed, so true is this, that any detailed description is rendered quite unnecessary.

Two points it will be well to note, however, for I believe, comparatively speaking, the cranial capacity in *Petrochelidon* is relatively larger than it is in *Progne*; and although the palatines are very much of the same shape, the postero-external angles in the former are more inclined to be rounded than truncated as they are in *Progne*.

Chelidon erythrogaster in this part of its skeleton probably typifies the Hirundine skull (Pl. XXI. figs. 21, 23).

In it the superior osseous mandible is very broad at its base, and the postero-external angles of the maxillaries have a tendency to project a little. The frontal region is more than usually narrow between the upper margins of the orbits. Laterally, we note that the vacuities in the interorbital septum are usually larger than in other Swallows, though yet but two in number, and of the same general outline. One thing characteristic of the skull of *Chelidon* is its uncommonly minute occipital condyle; I cannot recall at this moment any bird of the size of this Swallow which possesses this feature in anything like such diminutive proportions. Its pterygoids and the quadrato-jugal bars are also wonderfully slender osseous rods.

Agreeing almost exactly with the mandible in *Progne*, save in size, this bone in our Barn-Swallow requires no special mention. In the hyoidean arches, however, it would seem that ossification is regularly extended to the glosso-hyal and the cerato-hyals, which was not the case, as we will remember, in the Martin.

Passing to the genus *Tachycineta*, we meet with a skull, in either species representing it (*T. bicolor*, *T. thalassina*), which, although essentially Hirundine in all particulars, yet bears a closer resemblance to some of our other Oscines, not Swallows, than any of the other skulls of the *Hirundinidæ.* This is principally due to the fact that in the skull of *Tachycineta* the base of the osseous superior mandible is not nearly so broad in comparison as it is among the other Swallows, and consequently more nearly approaches in appearance the skull of some of those Passeres which possess mandibles with rather broad bases.

The structural details seen at the base of the skull in *Tachycineta thalassina* I have already shown in a previous memoir, wherein I have figured those parts in a specimen of that Swallow (P. Z. S. 1885, p. 899, fig. F); and as that figure is readily accessible to the reader, a comparison of it with the figures in the present paper may be made without difficulty.

Nothing worthy of special record is to be found in the *mandible*, nor in the *hyoid arches* of the skulls or the latter apparatus in the genus *Tachycineta*; they present all the true characteristics of those parts as already described above with sufficient fulness for the *Hirundinidæ* generally, and our present purpose.

What I have just said of the skulls and associated parts as found in the two species of the genus *Tachycineta* applies with equal truth to the corresponding structures as found in *Clivicola riparia* and in *Stelgidopteryx serripennis*, of which I have several examples of each before me.

In their general form they, too, remind us more of the skulls of certain other types of Oscines than do the skulls of the other Swallows which were described above, previous to our taking up the skulls of the genus *Tachycineta*.

Of the remainder of the Axial Skeleton in the Hirundinidæ.— My labour is considerably lightened here from the fact that I have already touched with some degree of fulness upon the axial skeleton of *Tachycineta* in my first memoir in the 'Proceedings of the Zoological Society' (1885, p. 906); and then, again, the sternum and shoulder-girdle of the Swallows is very well known, making any detailed account of it here unnecessary.

By those who have read it, it may be remembered that I found 35 vertebræ and a pygostyle in the spinal column of a Swift (*Micropus*), and the same number of segments in the column of a Swallow (*Tachycineta*). Upon careful examination I am now enabled to state that this is the normal number for all our Swallows, and I have yet to find an exception to it. Should such an exception be found, I predict it will simply be a free, and perhaps rudimentary, vertebra at the end of the series of the caudal segments.

Further, I find the arrangement of the free vertebral ribs and their uncinate processes the same for all Hirundinidæ, as I found them to exist in the Violet-green Swallow in my former memoir. This arrangement consists in their having 12 cervical vertebræ that do not possess free ribs; the thirteenth has a rudimentary pair; the fourteenth has them better developed, and even may have uncinate processes upon them; the fifteenth are the first to connect by costal ribs with the sternum, as do the ribs from the sixteenth to the nineteenth vertebræ inclusive. The twentieth is the first vertebra appropriated by the pelvis, and this latter compound bone monopolizes ten of these segments, so that the first free caudal is the thirtieth vertebra of the spinal column.

Thus far at least one Swift (*Micropus*) was found by me to exhibit an arrangement similar to this, and later on we may look into the matter for *Chætura*.

The Humming-birds possess, as I have elsewhere stated, but 32 vertebræ and a pygostyle in their spinal column.

Every species of our Swallows possesses a *pelvis* of a pattern characteristically its own, so that had we before us a dozen pelves of *Progne*, a dozen of *Chelidon*, and a dozen of each of the others we should have no difficulty, after once becoming acquainted with them, in picking out the several varieties correctly. Then, again, these pelves all strictly fall within the general description applied to what we please to call *a Passerine pelvis*, so far as our present knowledge and ideas of such a bone can be formulated. Now there is nothing that I can at this moment place my finger upon in the pelvis of a Swift that debars it from being classed in the same category; and indeed, when we come to examine into the matter closely, the differences between the pelves of *Micropus* and *Progne* are no greater than are the differences between the pelves of *Progne* and *Chelidon*.

Ornithologists have long ago placed on record descriptions of the *shoulder-girdle* and *sternum* of Hirundine birds, and the morphology of these parts in them is so well-known that to say, that although each species of Swallow has a characteristic form of sternum and shoulder-girdle of its own, these elements of the skeleton in all of them are strictly Passerine,—will sufficiently meet our aims in the present connection.

In my memoir in the P. Z. S. already referred to I made comparisons of these parts as they occur in *Micropus* and *Tachycineta*, and further on, when we come to examine the skeleton of *Chætura*, a few more words on the subject may be added.

Of the Skeleton of the Limbs in Swallows.—All of the Hirundinidæ agree with the true Passeres in having the little ossicle known as the *os humero-scapulare* at the shoulder-joint, but I have failed to find it in the Cypseline birds.

In the Proc. Zool. Soc. for April 1887 I figured the *humerus* of *Tachycineta thalassina*, and further on in this article I shall have to refer to that drawing. Now, so far as the humeri of the other Swallows are concerned, they all more or less resemble the bone as found in *Tachycineta*: they are invariably non-pneumatic, proportionately short in the shaft as compared with the size of the bird, and quite so relatively when taken in comparison with the Passeres generally. Especially in *Chelidon* is this brevity of the humeral shaft noticeable; and it becomes of interest to know that in a specimen of this Swallow I find a humerus 15 millim. long to an ulna 24 millim. long, and in *Progne* a humerus 22 millim. long to an ulna of 33 millim., while in a Swift (*Micropus*) we have a humerus 11 millim. long to an ulna of but 16 millim. in length, showing a difference of 9, 11, and 5 millimetres respectively.

Swallows have at least one good-sized sesamoid at the elbow, but I thus far have failed to detect any such small bone in a Swift; in *Micropus*, however, I find in the same tendon a small nodule of dense cartilage.

The shafts of both ulna and radius are noticeably straight for nearly their entire lengths, and in their general conformation depart but little from the usual form assumed by these bones in the Passeres at large.

I have already pointed out elsewhere that n a Swift (*Micropus*) these bones are also markedly straight, and are, comparatively speaking, almost as short for a bird of its size as is the humerus,—Swifts, as a rule, deriving their length of wing from the long bones of the pinion, and not from those of the brachium and antibrachium.

Radial and ulnar ossicles are found in the carpus of all Hirundine birds, as usual, and in their form and method of articulation no departure whatever is made from the composition of the wrist-joint, as seen in all others of the group.

There are no claws on the finger-end in the manus and phalanges, and the carpo-metacarpal bone is much of the same shape as we find it in Passeres generally.

To one point I desire to direct special attention, and that is—that in all Swallows in their carpo-metacarpal bone the metacarpal which belongs to the index digit is considerably *shorter* than the one which belongs to the annularis digit of this compound bone. This arrangement is strikingly apparent in such a bird as *Progne subis*, and it will be remembered that in *Trochilus* this is also the case, though not so marked; whereas in Swifts the reverse condition obtains, and the metacarpal of the index digit is rather the longer of the two.

Little need be said here in regard to the osteology of the pelvic limb of the Swallows, for from femur to phalanges it is characteristically Passerine, and in every species the relative lengths of the several long bones composing it are harmoniously proportioned. Be it noted, however, that Swallows always possess a *patella*, and that in them the pro- and ectocnemial processes of the tibia are always well developed, while the *fibula*, although often of only hair-like proportions (*Progne*), descends below the middle point of the shaft of the tibio-tarsus.

Further, in the hypotarsial process of the tarso-metatarsus there are four perforations for the passage of tendons, these openings being arranged as though they were at the angles of a square, one pair being next to the head of the bone, and the remaining pair immediately behind them.

When I come to review, further on, the characters of the pectoral and pelvic limbs of certain Swifts and Humming-birds, it will be necessary to revert again to some of these Hirundine characters as found in their limbs; and so it will not be necessary to enter more fully into details at this point, but rather reserve them for the more effective work of actual comparison.

ON THE MORPHOLOGY OF CERTAIN CYPSELI AND TROCHILI.

Of the External Form and Pterylography of certain Cypseline and Trochiline birds.

Very good hints sometimes as to a bird's affinities may be gathered from a study of its general contour and form after it has been carefully plucked for the purpose. With this in view, and in this way, I prepared specimens of *Micropus melanoleucus*, *Chætura pelagica*, and *Trochilus platycercus*, and present drawings of the same here to illustrate my meaning. A glance at the contour of *Micropus* will be sufficient to convince us that in general outline it is strikingly, indeed actually, far more like any one of our Swallows, as *Progne* for instance. And, apart from the resemblance which its short antibrachium gives it to *Trochilus* (Pl. XXIV. fig. 39), it has no other character upon this aspect of its body to support the view that any true relationship exists between it and the latter bird. For the rest, to my mind, shortness of the antibrachium amounts to nothing as an indication of affinity unless correlated with actual similarity of form in its details. *Chætura* having a deeper carina to its sternum than has the other Swift, *Micropus*, it bears a somewhat more general resemblance to the body of a Humming-bird (fig. 39) than it otherwise would do, or as does *Micropus*; but some of the smaller Petrels might hold an equal claim to affinity with *Trochilus* were it based upon such data as this.

Coming to a few of the true characters, we find the bill, the position of the commissure of the gape, the feet, and some other points widely different in a Swift from what the corresponding characters are in a Humming-bird; and when *Micropus* is the Swift chosen for the comparison, the *entire contour of its body* differs from that of *Trochilus* in all important particulars.

Let us next examine the pterylography of these three birds, and see what it indicates in regard to their affinity.

Nitzsch has presented us with fairly good figures of the pterylography of *Cypselus apus* and *Trochilus moschitus* (Pterylog., ed. Sclater, pl. iii. figs. 16–19); but there are several points requiring elaboration in his account, while in other particulars his comparisons are deficient.

Taking his figures and descriptions just as they stand, however, and bringing into the discussion his figure 14 on the same plate, of *Hirundo urbica*, we find that the pteryloses of the Swift and Swallow, so far as their heads are concerned, agree, with the exception that the Swift possesses those peculiar crescent-shaped apteria, one over each eye; these are absent both in the Swallow and Humming-bird.

But the Humming-birds have a median naked space of a spindle-shaped outline on the crown, situated longitudinally, and between the eyes and the base of the superior mandible. This is well marked in all species which I have thus far examined, and it was overlooked by Nitzsch; moreover, it is absent in the Swifts and Swallows.

On the throat of Swifts and Swallows the feathering covers the entire area, while in Humming-birds the median naked space of the neck is continued almost up to the base of the inferior mandible.

Again, Nitzsch noticed the naked "nape-space [see his figure] beneath the long cornua of the hyoid bone," but "could not determine with precision" whether or no it was a constant character for the pterylography in the *Trochili*. My investigations convince me that it is a constant character in them, and, further, that it is *never* present in the Swifts nor Swallows. If any one will take the trouble to pluck a Humming-bird and note, in the natural position of its head, that the back of the head comes very close to the body, he will see at once how this naked space has come to be present there.

The arrangement of the pterylæ upon the ventral aspects of all of these birds is more or less alike, being apparent modifications of some Passerine type; but not so with the spaces upon the dorsal aspects, for here we find that the true differences among them come in (compare Nitzsch's figures). And we must remember that Nitzsch, in speaking of the pterylography of the Macrochires, was forced to admit that:—"In this family I place the two genera *Cypselus* and *Trochilus*, which, indeed, present but little external similarity, but are very nearly allied in the structure of their wings" (p. 86). To the near alliance on account of the latter character we will revert later on.

In the first part of this memoir I have attempted to point out such differences as exist between the pterylography of a Swift and a Swallow, so it will not be necessary to enter so fully upon the details again here. Be it borne in mind, however, that, upon this dorsal aspect of the two, in both the *humeral tract* crosses obliquely *at a point opposite the middle of the humerus of the arm*; in *Trochilus*, on the other hand, *it is over the head of the humerus*. Swifts and Swallows both possess a femoral tract; whereas it is absent as a rule (and, for all that I know to the contrary, always) in the Humming-birds—certainly so in *Trochilus*.

In Swifts the "spinal tract" connects the capital area behind with the oil-gland, but just opposite the shoulder-joints bifurcates; the bifurcations are as wide as the original tract, and after passing the middle of the back they converge again, and unite at a point over the anterior end of the sacrum. Thus we find a spindle-formed figure produced, which is characteristic of the Cypseli.

In Swallows the bifurcation does not take place until the spinal tract arrives nearly at the middle of the back, and then the ends of the fork fail to join the rump-tract below.

Now in Humming-birds, and I have examined a great many excellent specimens of them, the "spinal tract" is altogether different from this, for it consists of a very broad, lozenge-shaped figure, spreading out over nearly the entire dorsal region, being prolonged in a wide nuchal strip which merges with the "capital area" anteriorly, while its lower angle rests upon the uropygial gland, and laterally spreads over the femoral region. Mesially, and in the middle of this lozenge-shaped area, we have a short longitudinal naked strip, but not nearly so conspicuous as it is in the Swifts.

Indeed, the pterylography of a true *Cypselus* and *Trochilus* is as different in character as any two forms of birds can well be in this particular; and if one, unprejudiced in mind, will look at plate iii. of Nitzsch's work, there will be seen a greater similarity between the dorsal tracts of *Cypselus apus* and *Coracina cephaloptera* than between *Cypselus apus* and *Trochilus moschitus.*

We are already aware that, notwithstanding Swifts and Humming-birds possess the same number of primaries and rectrices, it rather conveys the impression that this is more a matter of chance, when we find that they essentially *differ in their pterylography* and in the *number of secondaries in their wings.*

For another external character in the Swifts, and a very excellent one, which I have failed to find elsewhere described, we must turn to the integuments covering the pinion. Here we find the entire skin exclusive of the border surrounding this part of the limb, and on both sides, *of a deep black colour*, being produced by a pigmentary deposit in the skin itself. This peculiar character is present both in *Micropus* and *Chætura*, while it is entirely absent in *Trochilus.* Swallows also lack this pigmentary deposit in the skin on both surfaces of the pinion.

To conclude this chapter, then, I will make a few comparisons between the external forms and characters of *Micropus*—a true Swift—and *Trochilus platycercus*—a typical Humming-bird.

So far as the general form of these two birds is concerned, a glance at Pl. XXIV. figs. 37 and 39, will be sufficient to convince any one that they are *as different as they can well be.*

In the character of *their beaks* they are as widely different as any two types in the entire class Aves.

They differ essentially in *their pteryloses,* and in the number of the secondaries.

Their feet are *radically* different, quite as different, for instance, as are the feet of a Swift and a Sparrow-Hawk.

The majority of these differences in these two types are absolutely of an ordinal rank (for Aves).

And now, before entering upon their internal structure, let me add here the well-known fact that these birds also *differ essentially in their habits, their mode of nidification, and the manner of securing their food*; indeed, in all these particulars in their life history they are widely, very widely different.

A critical Comparison of the Pectoral Limbs of certain Cypseli *and* Trochili.

From time immemorial in Ornithology the two main characters upon which systematists have relied for retaining the *Cypseli* and *Trochili* in the same group of birds, as related forms, are the supposed similarity of the structure of their wings, and the fact that both possess an unnotched sternum. Finding that these birds widely disagree in so many vital, fundamental particulars, it is my object to compare them very critically with respect to their wing-structure, and the present section will be devoted to the results of my investigations in that direction. Swallows, as we know, possess a wing-structure very similar in organization to the Passeres generally, so it will not be necessary to make many comparisons with them in the same connection. We have just seen how essentially different the wing of *Trochilus* is from the wing of *Micropus,* so far as its external characters are concerned: to be sure they have a superficial resemblance, as both have short humeri and long pinions, but this resemblance gives way when we come to compare the parts in detail.

First, then, let us examine the method of attachment of the patagial muscles, surely a character which has proved itself to be a useful one, and one eminently connected with the wing-structure in birds, be they Swifts or Humming-birds. Now Prof. Garrod dissected a Humming-bird with the view of ascertaining the point which concerns us here, and he had a specimen of *Patagona gigas* for investigation. Moreover he made a drawing of his dissection of the parts in question, and it may be seen in figure 1, plate xxiv. of his 'Collected Scientific Memoirs.'

With the exception of leaving off the lower *extensor* of the forearm, his drawing is correct, and from it we see that the *tensor patagii longus* arises and is inserted pretty much as we find it in most birds: but with respect to the *tensor patagii brevis* a very marked departure is met with, for that muscle is as prominent as any other in the arm, more so than the majority of them. It may be said to be somewhat pear-shaped in form, with its larger end at the origin at the shoulder, while the smaller extremity becomes attached to a tendon which passes directly over the upper surface of the *extensor metacarpi radialis longior*, longitudinally.

This tendon arises at the outer condyle of the humerus, and passes to the carpus for insertion, and is very well shown in Garrod's drawing of *Patagona*.

I find it present in all the *Trochili*, where, so far as I know, it constitutes a unique method of insertion for the *tensor patagii brevis*, and to make it clearer I present a drawing of it for *Trochilus platycercus* (Pl. XXII. fig. 28).

Since Garrod saw so clearly this very unusual insertion of the *tensor patagii brevis* in the Humming-birds, I am surprised beyond measure that he did not at once make *careful* comparisons with the Cypseli in this particular; had he done so, he would have found, as I have, that the mode of insertion of this muscle in those birds is *entirely different*. In the first place the body of the muscle is comparatively much smaller; it is also of a very different form, being oblong and not pear-shaped; finally it *is not inserted into any special tendon*, but directly upon a tendinous fascia on the surface of the *extensor metacarpi radialis longior*, and its fibres, becoming slightly tendinous, run down with that muscle for insertion at the external condyle of the humerus. In Pl. XXII. fig. 29, I present a drawing made directly from my dissection of these parts in a specimen of *Chætura pelagica*.

As both the Humming-birds and Swifts have short humeri (though "shortness" is not a character, I believe) and have developed a large *tensor patagii brevis* (though "size" is not a character either, I believe) it might not unnaturally be expected that they should have this particular muscle *short and thick*; but when we come to examine the true morphology, how vastly different is it! Quite as different, we may say in truth, as are the humeri of these birds.

The *tensor patagii longus* in *Chætura pelagica* has the usual origin and insertion that it has in so many of the Class.

Cypseli and Trochili both possess all three *pectoral muscles*, but in such a form as *Micropus* they are none of them unduly developed; better so in *Chætura*; while in the Trochili they are, comparatively speaking, enormously developed.

Owing to the entirely different shape of the humerus in Swifts and Humming-birds, the tendons of the pectorals make dissimilar insertions. For instance, the *pectoralis major* in *Micropus* is inserted upon the entire palmar aspect of the large hook-like radial crest of the humerus of that Swift; but *Trochilus* possessing no such process upon its humerus, the muscle is obliged to insert itself more or less upon the body of the bone, at a point which would be considered as the base, upon the palmar side of a radial process did such a thing exist there.

Now the *pectoralis secundus* in *Micropus* is inserted at the head of the humerus upon its anconal side, between the summit and radial crest or hook; while in the Humming-bird this second pectoral sends its tendon *across* the head of the bone, to be inserted at the distal margin of the pneumatic fossa. The insertion of the *third pectoral* in these two groups of birds is more similar.

So here, again, we see that Swifts and Humming-birds are markedly different with respect to another class of muscles which make up, in part, the fundamental organization of their wing-structures.

Among the essential characters of the wing we still have left the skeleton, but I have already published my views and drawings in regard to that part of their economy elsewhere (Proc. Zool. Soc. 1885 and 1887). I have there shown conclusively that the humeri of Swifts and Humming-birds are very differently formed bones indeed, and the reader has but to refer to the figures in the papers to which I allude to be convinced upon this point.

As I have elsewhere stated, the humerus in *Micropus* is a non-pneumatic bone as in the Swallows; while all Humming-birds, so far as I have examined, have pneumatic humeri. Still my statement Proc. (Zool. Soc. 1887, p. 503) requires some modification, for since that was written I have found that the humeri in *Chætura pelagica* are pneumatic, but the bone is shaped upon the same plan as the humerus of *Micropus*, and the *pneumatic fossa is*, as in Passeres, *on the ulnar side*. From what has gone before, we now know that in *general form*, and other particulars, *Micropus* is nearer the Swallows than is such a Swift as *Chætura*, and this last fact, with respect to the arm-bones, points still more strongly to the truth of such a statement. Even at this moment I am not acquainted with any other bird in the Class that has the pneumatic fossa of its humerus situated on the radial side of the bone, as the Trochili have. This fact alone, and surely when taken in connection with the otherwise vastly different form of the bone itself, is sufficient to show that in their wing-structure Swifts and Humming-birds widely differ.

Further, in the papers above alluded to I have already pointed out how in the bones of the antibrachium, in *Trochilus* and *Micropus*, the radius is actually bent to a bow in the former, while it is as absolutely straight as any bone can be in the Swift. The ulna, too, in these birds differs in its general form. Moreover, we find sesamoids present in the carpus of Humming-birds which do not exist in Cypseli, although, since writing my first memoir on this subject, I have found a sesamoid at the elbow in *Chætura* and *Micropus*, such as the Swallows have.

Coming next to the carpo-metacarpus we find one great and principal difference, in addition to minor ones—in the Humming-birds the middle metacarpal in this compound bone is *longer* than the index metacarpal, the reverse condition obtaining among the Swifts. This is enough to show that the bones are essentially unlike in their most important character. The proximal phalanx of the index finger is altogether a differently formed bone from the corresponding segment in the manus of the Swift, as any one may see by a comparison either of the bones themselves or my drawings (P. Z. S. 1885, pl. lxi. figs. 3 and 4, *j*).

To briefly recapitulate, then, the absolutely essential and fundamental characters in the wing-structure of a Swift and a Humming-bird, I find that:—1. The parts markedly differ in their external characters, inasmuch as they do not possess the same number of secondary quill-feathers; Swifts have a very peculiar pigmented (deep black) area of the skin centrally located on both sides of the hand, while Trochili have not; the character of the plumage is quite different; and the *position of the "humeral tract" in the pterylosis* is different, being across the middle of the humerus in Swifts, and overlying the head of the bone in Humming-birds. 2. The mode of insertion of the *patagial muscles*, as well as the *form* and *character* of these muscles themselves, is altogether different in the two groups. 3. The method of insertion of the *pectoral muscles* is essentially different. 4. Throughout the entire skeleton of this limb, the individual bones in Swifts and Humming-birds differ widely in characters of the very highest import, both morphologically and in the position, absence, and presence of parts.

All this being so, I am firmly convinced that were the minor details in structure in these two wings carefully worked out under the lens of a good microscope, they too, of necessity, would also be found to be at variance. Indeed, in making my own dissections of the Trochili under a 2-inch objective I saw quite enough to fully confirm this suspicion.

Finally, I must say, as I have already remarked in a previous paragraph, that heretofore too much stress has been laid upon the fact that both Cypseli and Trochili possess *short humeri*; and, further, to my mind, *shortness, per se*, does not constitute a valid character, for if it did, some very remarkable forms would surely be grouped together! My painstaking labours upon the wing-structure of Swifts and Humming-birds convince me fully that, in so far as this part of their organization is concerned, there is little or no affinity at all.

Notes on the Anatomy of the Pelvic Limb in certain Cypseli *and* Trochili.

Having shown how innately different the wing-structure in Swifts and Humming-birds really is, let us now take a look at their pelvic limbs.

It will not be necessary to pass the external characters of these parts in review, as they are already well known; it will be sufficient to remark that the pelvic limb of such a bird as *Micropus* differs from the pelvic limb of a *Trochilus* in all its more essential external characters.

My investigations tend to confirm the statement of Professor Garrod, that Humming-birds and the American Swifts *Chætura pelagica* and *Micropus* lack the accessory femoro-caudal, the semitendinosus, and the accessory semitendinosus muscles from the group at the thigh; in other words, their formula is A.

This from a physiological point of view would naturally be looked for, as no members of these groups use their limbs for locomotory purposes; and consequently these special muscles have long since been missing, or perhaps in neither of them have they ever been present. But to this matter I shall refer further on.

Coming next to the *plantar tendons*, I find the arrangement in the Swifts at hand the same as described by Garrod for *Cypselus alpinus* (Coll. Scient. Mem. p. 294), and as that has already been made clear to us, I need not quote it here; but after having carefully prepared the foot of a specimen of *Trochilus platycercus*, and bringing the limb under the lens of a powerful objective, which increased the size of this Humming-bird's foot to that of a Crow, I was enabled at once to discover that the arrangement of the plantar tendons in these birds is very different from what obtains in the Cypseli; in other words, in *Trochilus* these tendons are disposed very much as we find them in the Passeres, where the tendon of the *flexor longus hallucis* is distinct from that of the *flexor perforans digitorum*. It is just possible that in Humming-birds a slight vinculum may connect the two, and although I could not quite satisfactorily demonstrate this minor point, yet I am inclined to think that such a vinculum is present.

I found the *sciatic artery* the main artery of the leg in both Cypseli and Trochili, but that is the usual arrangement for nearly all birds, which weakens its importance as a distinctive character.

As to the skeleton of this limb in these birds I have already contributed some work (P. Z. S. 1885, pp. 909-913), and little or nothing need be added here. Suffice it to say that morphologically the constitution of the pelvic limb, so far as its skeleton is concerned, is radically different in Cypseli and Trochili. A few points will be sufficient to convince any one of this fact, for in *Trochilus*, for instance, we have a large *patella* present, a bone *entirely missing* in *Micropus*; in *Trochilus* we have the hypotarsial process of the tarso-metatarsus *both pierced* and *grooved* for the passage of the tendons, whereas in *Micropus* it simply exhibits *one deep groove* for that purpose; finally, the foot in each case is widely different, for in *Trochilus* the joints of pes stand 2, 3, 4, 5, while, as we know, in ***Micropus*** they stand 2, 3, 3, 3.

As existing birds are classified, and were two such forms as ***Micropus*** and ***Trochilus*** classified upon the characters presented in their pelvic limbs alone, all I can say is, that to my mind there should be no hesitation whatever in placing them in widely separated groups, notwithstanding the fact that the myological formula of the thigh-muscles is the same. For even when we come to examine these very muscles closely we soon discover that they are quite *differently formed and disposed*, which should also be taken into consideration in face of the fact of the mere presence or absence of parts.

For the rest, the limb in these two groups of birds to its very toe-joints is about as essentially different as are the limbs of an Ostrich and a Coot.

On the Anatomy of the Head.

Were I asked to pick out any two forms of existing birds from any part of the world which present us with the greatest number of fundamental differences so far as the anatomy of the head is concerned, it would puzzle me, I think, to select two more diverse types than a true Swift and a Humming-bird. Indeed, from tip of beak to nape it is difficult to find comparable characters that show any affinity of the forms in question at all. I have already pointed out above the very evident differences that are exhibited upon a comparison of the external characters of such a Swift as ***Micropus*** and any of the Trochili; while the principal differences in the skulls of these birds have been already dwelt upon *. And has the day yet arrived when differences of the most manifest character in the skulls of birds are to be ignored in taxonomy, and set aside as of no value?

At the present time I have before me upwards of a hundred anatomical specimens of Trochili and a great many Swifts; but for a brief *résumé* of some of the distinctive cranial characters let us choose a specimen each of *Chætura pelagica* and *Trochilus rufus*, and see how they compare in these two types. We find these characters to be as follow:—

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* Proc. Zool. Soc. 1885.

Chætura.	*Trochilus.*
1. Superior mandible wide and not produced.	1. Superior mandible narrow and usually twice as long as the head.
2. Triangular openings between nasals and frontals, divided by the premaxillary.	2. No such openings present.
3. Cranium above smooth and rounded.	3. Cranium above showing a deep, longitudinal groove for ends of hyoid.
4. Vomer truncated.	4. Vomer long and spine-like.
5. Maxillo-palatines prominent and produced well backwards, tending to approach mesially.	5. Maxillo-palatines not prominent, rounded, and wide apart.
6. Postero-external angles of palatines produced as prominent processes.	6. External margin of each palatine nearly straight, and no *angle* present.
7. Palatine heads of pterygoids nearly meet mesially.	7. Palatine heads of pterygoids widely separated mesially (and I have seen specimens where they *anchylosed* to the palatines).
8. Pars plana small and formed as in Swallows.	8. Pars plana very large, and very different from the Swallows.
9. Interorbital septum shows several vacuities, and these are distinct from those on the posterior orbital wall.	9. Interorbital septum never shows but one vacuity, which merges with one that absorbs nearly all the posterior orbital wall.
10. Mandible a wide V, without ramal vacuity.	10. Mandible a long and extremely narrow V, with ramal vacuity.

In short, these skulls evidently belong to very different Orders of birds, and their differences upon a lateral view can be well appreciated by examining and comparing figures 24 and 27 of Plate XXII.; the Swift there figured, however, is ***Micropus***, but will answer just as well.

Carefully comparing *the brain* in several specimens of Humming-birds of different species, with the brains of Swifts and Swallows, I find that, although in all three groups the brain and its parts are strictly fashioned upon the true avian plan, in the Swifts and Swallows its general and special form is far more alike than it is when we compare it with the brain in a *Trochilus*. This we might naturally have looked for, since the inner shape of the cranial casket in the Humming-bird is very different from the corresponding cavity in the Cypseli and Hirundines.

Another structure which need not detain us long is *the tongue*.

This organ is essentially alike in Swallows and Swifts; while, as we all know, in the Trochili it is more as we find it in the Woodpeckers, indeed very similar to those birds, for I find after careful microscopical examination that there is no truth in a statement still current that this long, slender tongue of *Trochilus* is a double-barrelled tube to suck honey with, but these supposed hollow tubes contain the prolongations of the cartilaginous parts of the glosso-hyal elements of the hyoidean apparatus.

With these few brief comparisons, which, however, are the expressions of long and painstaking dissections upon the heads of these several forms, I may state that, so far as this part of the economy is concerned, Cypseli and Trochili are *widely different in all particulars*, whereas Swifts show themselves to be but highly modified Hirundine birds.

Résumé of some of the Points in the remainder of the Axial Skeleton.

These I will tabulate in order to bring them into as bold relief as possible for direct comparison. In the Proc. Zool. Soc. 1885, I have already made some remarks upon the skeletons of *Micropus melanoleucus* and *Trochilus Alexandri*. Here, for variety's sake, we will take the Swift *Chætura pelagica* and *Trochilus rufus*: they are essentially and respectively much alike, at any rate the two first mentioned species, but I do this in order to show that my first comparisons still hold good for the proposed separate groups.

Chætura pelagica.	*Trochilus rufus.*
1. 12 cervical vertebræ that are without free ribs; 13th and 14th vertebræ possess freely suspended ribs; while from the 15th to the 19th they are *true dorsals*, connecting with the sternum by costal ribs.	1. 13 cervical vertebræ that are without free ribs; only the 14th vertebra possesses freely suspended ribs; while the 15th, 16th, and 17th are the only three free vertebræ in the dorsal region which connect with the sternum by costal ribs. The 18th and 19th likewise do; but I here propose to consider these two latter ones as *leading sacrals*, as they evidently belong to that bone. This gives *Trochili* but *three true dorsal vertebræ*, quite as few as any other existing bird, and it is all they have.
2. The last sacral vertebra is the 29th.	2. The last sacral vertebra is the 27th.

Chætura pelagica.	*Trochilus rufus.*
3. The last caudal vertebra is the 35th.	3. The last caudal vertebra is the 32nd.
4. Pelvis much as we find it in some Swallows; leading sacral vertebra does not markedly project beyond ilia.	4. Pelvis peculiarly formed; and two entire vertebræ project beyond the ilia (the 18th and 19th).
5. Sternum untouched posteriorly; possesses comparatively large costal processes; small manubrium; deep carina; which latter and the body are *always* riddled with large vacuities.	5. Sternum unnotched posteriorly; very small costal processes; no manubrium; comparatively a much deeper carina; sternal body and keel never perforated by vacuities.
6. Os furcula a very broad U-shaped one, with lateral abutments at its heads, and with rudimentary hypocleidium; the bone harmoniously proportioned for the rest of the skeleton.	6. Os furcula rather of a very broad V-shaped variety, with small lateral abutments at its heads, and with rudimentary hypocleidium, with the bone of hair-like dimensions as compared with others of the skeleton.
7. Coracoids much of the same form as we find them in the Swallows.	7. Coracoids very peculiar, as the tendinal canal is closed by bone, and the shaft perforated by a large foramen below it. *Totally* unlike the bone in the *Cypseli.*
8. Blade of scapula nearly straight.	8. Blade of scapula bent at a marked angle at its posterior extremity.
9. General aspect of the body skeleton, aside from the unnotched sternum and rather deep keel to it, like the *Hirundinidæ.*	9. General aspect of the body skeleton has no exact counterpart among living birds, that the writer has as yet ever met with.

Now a few words as to what the above table shows: first, it is evident that the spinal column of Swifts and Humming-birds is fundamentally different, both in the number and arrangement of the vertebræ. It should, however, be stated that upon going over a large number of specimens, I find that it is the 15th vertebra that first connects with the sternum by costal ribs, and not the 16th as stated in my first contribution of 1885. This gives the Trochili 3 true dorsals, which is as small a number as any existing bird possesses; I found the same number in a Californian Condor. Cypseli *possess 5 true dorsal vertebræ.*

Some excellent characters, no doubt, are to be obtained from any bird's sternum, but the more I look into it the more I am convinced that the facility with which we can say sternum 2-notched, sternum unnotched, sternum 4-notched (as the case may be) has almost proved a detriment to avian taxonomy, for, being satisfied with that (taken in connection with a few other salient characters), very often the rest of the bird's economy has not been examined nor even taken into consideration at all. Why the pelvis has not proved an equally valuable character in the list of classificatory characters, is simply because the systematist cannot so readily say pelvis 2-notched, pelvis unnotched, and so on. Yet the pelves of birds, when carefully compared, offer fully as good distinctive characters for taxonomic purposes as the sternum. I have already pointed out the fact that the pelvis of a *Trochilus* is as different from the pelvis of a *Cypselus* as any two birds' pelves can well be. Further, their sterna, when we really take all their characters into consideration, apart from the fact that both happen to be unnotched, are very differently fashioned bones. Both are unnotched, to be sure,—but so are the sterna of some Petrels! Were the fact that the sterna of both Cypseli and Trochili are unnotched of any significance, so far as affinity is concerned, then surely the remainder of the organization in these birds would be more or less in harmony, and not at the widest variance, as is the case! What I mean by this is easily shown in the shoulder-girdles of the two types in question: thus, the coracoid of a *Trochilus* is a very uniquely-formed bone (P. Z. S. 1885, pl. lx. fig. 5), and very different from the great majority of birds. In the Swifts the coracoid is like that of the Swallows. Again, the scapula in *Trochilus* is unlike the corresponding bone in a Swift: consequently, this being the case, I attach little or no importance, so far as affinity is concerned, to the fact that their furculæ happen to possess some marked resemblance. For we well know that this latter component of the girdle is that which becomes modified in accordance with the flight of its owner, while the coracoid can be far better relied upon for any affinity it may show as a character amongst forms more or less related. Swifts are birds of long-sustained flight, Humming-birds are great fliers, and so are Albatrosses; and were we to increase in size the os furcula of a Swift and a Humming-bird to the size of the bone in an Albatross, we should be surprised to find how much they resemble each other.

Seeing now how very different the thoracic and pelvic, or really the trunk-skeletons of Swifts and Humming-birds actually are, let us next examine into some of the organs and viscera which they enclose.

The Heart and Carotids, Trachea, Viscera, &c.

Cypseli as a rule possess but a single carotid, the left one; Professor Garrod, however, discovered that *Cypseloides* proved an exception to this. In *Chætura* I found but one, which was disposed along the anterior aspect of the neck in the most usual manner; while in *Micropus melanoleucus* the left carotid, here also the only one present, takes on a peculiar course, for being so far over to the left, it passes up to the front of the neck obliquely, and completely outside the protection of the muscles and the hypophysial canal of the vertebræ.

Past the middle point of the neck, however, it enters between the muscles to the aforesaid canal, and then follows the usual course to the head.

Swifts do not possess a heart of any unusual dimensions; but Humming-birds, on the other hand, have a heart quite as unproportionately large for their size as are the feet of these, the otherwise pygmies of the Class. They too have but one carotid, so far as I have examined, the left one alone being represented.

MacGillivray, in Audubon's 'Birds of North America,' under the latter's account of *Trochilus colubris*, presents us with a very good description of the trachea in a Humming-bird. He says of it that "The trachea is 9 twelfths long, being thus remarkably short on account of its bifurcating very high on the neck, for if it were to divide at the usual place, or just anteriorly to the base of the heart, it would be 4½ twelfths longer. In this respect it differs from that of all other birds examined, with the exception of the Roseate Spoonbill (*Platalea ajaja*), the trachea of which is in so far similar. The bronchi are exactly ½ inch in length. Until the bifurcation, the trachea passes along the right side, afterwards directly in front. There are 50 rings to the fork; and each bronchus has 34 rings. The breadth of the trachea at the upper part is scarcely more than ½ twelfth, and at the lower part considerably less. It is much flattened, and the rings are very narrow, cartilaginous, and placed widely apart. The bronchial rings are similar, and differ from those of most birds in being complete. The two bronchi lie in contact for 2 twelfths at the upper part, being connected by a common membrane. The lateral muscles are extremely slender. The last ring of the trachea is four times the breadth of the rest, and has on each side a large but not very prominent mass of muscular fibres, inserted into the first bronchial ring. This mass does not seem to be divisible into four distinct muscles, but rather to resemble that of the Fly-catchers, although nothing certain can be stated on this point." My own investigations upon other species than *T. colubris* go towards establishing in the main this admirable description of a very painstaking anatomist, for whom I have always entertained the highest regard both for his character and his work. It is needless to add that such a trachea, the counterpart of which is seen only in the Spoonbill, is sufficiently far removed from the form it assumes in the Cypseli to satisfy the most sceptical as to any affinity on that point! In Swifts it *does* bifurcate "at the usual place;" it possesses but *two* pairs of muscles (the lateral ones, and those that go to the sternum), and in all other points is widely and fundamentally at variance with the windpipe and bronchi of the Trochili.

Careful as MacGillivray's account is, however, he neglected to mention one very important difference, so far as these parts are concerned in the birds under consideration, and that is, the Trochili constitute one of those rare groups which lack the pair of *sterno-tracheales* muscles; I carefully searched for them in several species of Humming-birds, but failed to find them, and am quite convinced they do not exist.

If the reader will kindly turn to figure 33 of Plate XXIII. illustrating this memoir, he will find my drawing of the trachea of a Humming-bird, and in figure 35 the position it occupies in the thorax and neck with respect to the other organs.

Indeed, in figures 35 and 36 I have drawn the bodies of a Humming-bird and a Swift, after having carefully removed the pectoral muscles and sternum, in order to show this very thing. A glance at these two figures will be sufficient to satisfy any one as to the remarkable difference they present. In the Humming-bird, we are struck at once by the position of the trachea; the *direct* course of the left carotid, the *enormous heart*, and the fact that the low position of the liver conceals from our sight all the other viscera harboured in the abdominal cavity. Here, as in most birds, the right lobe of the liver is the larger of the two, which in the Humming-bird, as we see, curls round the apex of the heart (more so in *T. platycercus*), modelling itself to that extremity of it. Still more at variance, as compared with the Swift, is the *digestive tract* of a Humming-bird, for, so far as I am familiar with the morphology of the group, in none of them do I know of a species which possesses, as compared with the size of its intestines, so exceedingly small a stomach! This organ, together with the relatively large intestine, with, too, its bulbous cloaca, I have represented in figure 34.

Swifts possess a stomach, both in position and general form, very much like the Swallows, and, as we now know, nothing at all like the Trochili. True, neither Cypseli nor Trochili possess intestinal *cæca*; but does this mean anything when no other two organs in the bodies of these birds have any resemblance to each other whatever, so far as affinity is concerned? Look at them in the figures; are there many birds in the Class more widely separated in this respect than these Swifts and Humming-birds?

Upon laying open the stomach of a specimen of *Micropus melanoleucus*, I found it packed full of insects; but, what is more important, anatomically speaking, I discovered it to be lined with a tough, corneous, inner coat, which was lifted out *entire*, by simply using very gentle traction, with a pair of dissecting-forceps. The stomach of the Humming-bird was also full of the tiniest Coleoptera imaginable, which were very interesting to study under a two-inch objective attached to my Beck's binocular microscope, and I wondered as I did so whether all these tiny New-Mexican beetles were known to science.

Apart from the fact, then, that Cypseli and Trochili agree in certain numerical and negative characters ("a single carotid, and no cæca," dangerous facts sometimes!), these birds are by no means related, so far as the organs we have just been investigating are concerned.

Having now passed in review the characters of a Passerine bird (*Ampelis cedrorum*), and gone very carefully over the osteology of certain Trogons, and even yet more thoroughly over the structure of many *Caprimulgi*, Swallows, Swifts, and Humming-birds, I believe, as my views have been slowly formulating during my painstaking dissections, that I am now in a position to reconsider what I have already published upon the classification of the MACROCHIRES, as well as to present the conclusions at which I have now arrived, aided as I have been by all this recent research. Before doing this, however, I desire to present in a few paragraphs the results of my investigations upon two specimens of *T. Calliope*, nestlings only a day or two old, and for which I am indebted to the generosity of Mr. F. Stephens, of San Bernardino, California, who sent them to me to be used in the present connection. One of these little fellows I drew, life-size, and it will be found figured on Pl. XXIII.

fig. 32, which gives its external characters sufficiently well to obviate the necessity of a special description. Among the most interesting of these features is the wonderfully short beak in this nestling, as compared with the long slender one of the adult.

Supplementary Notes on Cypseloides niger *and* Nyctidromus albicollis, var. Merrilli.

As this paper is passing through the press I am able to add a few words upon the structure of these two birds—the Black Swift and Merrill's Parauque. This affords me particular satisfaction, for inasmuch as every species of American (*i. e.* United States) Swallow (seven in all) is anatomically described in this memoir, I can add that I have similarly examined and compared every species of Caprimulgine (except *A. carolinensis*) and Cypseline bird. I am indebted to my friend Professor Newton, F.R.S., of Cambridge, for the specimens of *Cypseloides*, which were collected for him on my behalf in Jamaica by Mr. G. A. Waddington. The specimens of *Nyctidromus* are from Texas, where they were procured on the lower Rio Grande by two of my collectors.

Externally *Cypseloides niger* has a more Swallow-like appearance than either *Micropus* or *Chætura*. This no doubt is due to the structure of the tail and feet, which have a more passerine appearance than is seen in *M. melanoleucus*, and still more so than in *C. pelagica* or *C. Vauxi*. Nevertheless *Cypseloides* is a Swift, with the pterylography of the order as given above. It also exhibits the peculiar black pigmentation on the palmar aspects of its pinions, although the skin there is not quite so dark as in other North-American Cypseli. The tarsal and pedal integuments are skinny, but plainly show a scutellate definition. The hind toe is somewhat elevated, though distinctly posterior in position. In general form the plucked body presents the appearance of the nude body of a *Chætura* rather than of *Micropus*, which is more compressed in shape.

Myologically, this Swift agrees with others already described, the patagial muscles, the muscles of the thigh, and thorax being almost identical with those of *C. pelagica*.

Upon opening the abdominal cavity we find that in these parts also *Cypseloides* agrees with all true Swifts. The stomach is notably large, and only overlapped by the lobes of the liver above, in all these respects differing widely from the corresponding organs in any existing Humming-bird.

In the anatomy of its air-passages, its heart and vascular system, this Black Swift is likewise typically Cypseline.

Coming to the skeleton, I find *Cypseloides* in its osteology agrees in the main with the group of birds to which it naturally belongs; that is, it is essentially a Swift so far as this part of its organization seems to indicate; nevertheless, in several particulars it has a skeleton nearer the Swallows than has either *Micropus* or *Chætura*. It has, for instance, the interorbital septum much as we find it in the *Hirundinidæ* generally, and a large sesamoid at the elbow, as in Swallows. But, what is still more significant, it has the vacuities, one on each side of the posterior mid-end of the premaxillary above, just beyond the frontal region, filled in by a thin continuous layer of bone—agreeing in this particular respect with the Barn-Swallow (*C. erythrogaster*). *Cypseloides*, moreover, has its external narial apertures more circumscribed, or, in other words, more as we find them in certain Hirundines (see figures 22 and 23, Plate XXI.).

Having compared the skeleton of *Nyctidromus albicollis* var. *Merrilli* with the skeletons of the other Caprimulgine birds of the U.S. avifauna which I have described on former occasions, I find that it agrees more nearly with the American Whip-poor-will (*Antrostomus vociferus*) than with any other. Osteologically, however, it may be found to agree still more closely with the "Chuck-will's-widow" (*A. carolinensis*), but as yet I have not had the opportunity of comparing it with that bird.

The entire order of the CAPRIMULGI stands much in need of thorough revision, and extensive researches into structure will be required before we can know much of the true relationships and proper classification. I am convinced that, so far as the United-States forms of this group of birds are concerned, there are certainly two very well-defined subfamilies of the *Caprimulgidæ*. From what we know of their external characters, and from what I have shown of their widely different internal structures, these might readily be characterized as the subfamilies *Antrostominæ* and *Chordeilinæ*—the former to contain the genera *Antrostomus*, *Phalænoptilus*, and *Nyctidromus*; the latter the genus *Chordeiles*.

We have but to compare the skull of Nuttall's Poor-will (*P. Nuttalli*, Plate XX.) with the skull of *Chordeiles acutipennis* var. *texensis* (P. Z. S. 1885, pl. lix.) to be convinced of the wide differences which exist in this part of the skeleton in these two very distinct kinds of Goatsuckers, and this, as we now know, is sustained by other parts of the structure of the birds in question. In this connection, however, I may add that I have recently examined a nearly adult specimen of *Chordeiles virginianus*, kindly procured for me by Dr. W. S. Strode of Bernadotte, Illinois. In this I find that the maxillo-palatines do not meet in the median line, but are pressed close against the sides of the *vomer* on each side. This latter bone is bifurcated behind, and into the fork the antero-median point of the palatines is wedged. The vomer comes well forward, anteriorly, where it is bluntly pointed and thicker than it is behind. It is only in the immature bird that these true relations can be studied, for in all species of this genus, as they attain to maturity, these several bones indistinguishably fuse, and present the appearance shown in the basal view of the skull of *Chordeiles acutipennis* var. *texensis* (P. Z. S. 1885, pl. lix. fig. 4), where, however, the *vomer* is not quite correctly indicated, for the lines designated by *Vo* go to the mesial fused portion of the palatines, and not to the vomer, which in that skull is co-ossified with the maxillo-palatines, and only its median line and anterior apex are seen.

Anatomical Notes upon the Nestling Trochilus, *a day or two old.*

First, I remove the delicate skin from the specimen's head, and note that the ends of the *hyoidean apparatus* have not proceeded beyond the posterior area of the parietal region, and that, although *the tongue* is short, still it shows well the embryonic condition of the two glosso-hyoidean rods which become so long in the adult Humming-bird.

The *nasal bones* lap rather high up on the frontal region, and mesially meet the backward-extending limb of the premaxillary for their entire borders, thus leaving no vacuity in this locality, as is to be seen in the postero-culmenar space of the superior aspect of the upper mandible in an adult *Cypselus*.

In size, the *lacrymal* bones are exceeding small, and I am inclined to think that were we able to define their sutural boundaries in the skull of the adult, we should find that they contribute but a meagre share to the wide expanse of bone in the pars plana of the mature *Trochilus*.

At the base of the skull we note that the tiny palatines, the jugals, quadrato-jugals, and even pterygoids are now considerably ossified; and that the latter elements are separated at their palatine heads quite as much in proportion as we find them in adult skulls.

The *premaxillary* and *mandible* are also largely formed in bone, more especially their tips and backward-extending limbs.

Removing the skin from the back, I carefully count the vertebræ of the column two or three times, distinguishing 35 segments, from which we may judge that 3 vertebræ are incorporated in the *pygostyle* of the adult.

Without any difficulty whatever, and by the aid of a 2-inch objective, I clearly make out the arrangement of the muscles of the fore limb, and distinctly perceive the tendon into which the tensor patagii brevis is inserted. Even still better can be seen the muscles of the thigh, where the biceps seems to arise by a double head from the pelvis, but otherwise the myological formula here is the same as I stated it above for the adult *Trochilus*. The plantar tendons also confirm all that is recorded in a preceding paragraph.

Coming next to *the sternum*, I find that even at this tender age the posterior margin of the body of the bone is rounded and unnotched. Six *costal ribs* articulate, on either side, with a "costal border."

At the side of the neck in this specimen the œsophagus was much distended by a small spider and two small beetles; but I believe that this represents food that the little bird had not swallowed at the time of its death, and that naturally no enlargement takes place in the œsophagus at the point in question.

We note that the bifurcation of the *trachea* is situated fully halfway up the neck towards the throat in this nestling, so that if the upper moiety of the anterior cervical region happens to be covered with the finger at the time of microscopical examination, one is momentarily impressed with the notion that the bird has two tracheæ, so unusual is this arrangement in the Class *Aves*.

Upon opening the thorax and abdomen, it disclosed the fact that the *sterno-laterales* muscles of the trachea are not present, and I am inclined to believe that *Trochili* do not possess them. Further, we find the heart is in about the same position and relative size as it is in the adult; but the *lobes of the liver* are proportionately much smaller, so much so that we can easily examine the intestines and stomach below their hinder borders without disturbing them, which is not possible in the adult.

On the other hand, *the stomach* is proportionately much larger in this nestling than it is in the parent bird (to be of any use, it could scarcely be of a relative size), and in the present case was crammed full of insects.

CONCLUSIONS.

Before touching upon the real object of the present memoir as stated in its title, in these my final conclusions, I will briefly allude to what may be gathered from my investigations as set forth in the earlier sections of this paper, touching the morphology of representatives of certain outlying groups to the MACROCHIRES. At the outset, believing it would be an advantage to pass in review the structure of a suitable and average Oscinine bird, I chose *Ampelis cedrorum* for reasons already fully stated; and, in addition to the advantage of having its structural characters before us in the present connection, my brief account of its anatomy, it is to be hoped, will prove useful in other particulars, more especially in throwing some light upon its own probable relations to the Clamatorial birds and the *Hirundines.*

It is believed that the account tends to show that structurally *Ampelis* presents no special affinity with the Swallows, while in some respects it links the Mesomyodian birds with the Oscines, though nearly all its entire organization points to its more intimate relations with the latter group.

Judging from osteological premisses alone, it is very evident that such forms as *Trogon puella* and *T. mexicanus* can claim no special relationship with the *Trochili,* while, on the other hand, I consider that their affinity with the Caprimulgi is also very remote. Further than this their kinship at present concerns us not, as it does not especially bear upon the work in hand; nor, even were I so disposed, would I hazard an opinion in any such direction, until I had fully investigated the structure of other birds specimens of which, up to the present time, it has not been my good fortune to possess, nor, in many instances, even to see. How much Cuckoo stock they possess in their economy is another point which can only be settled, if ever, by exhaustive researches into the anatomy of the more aberrant Cuculine types; it is more probable that they, the Trogons, came up through some such tribe as the latter, than through any other with which I am acquainted.

Still, and to hold this end of the thread for a moment longer, it is difficult to see any near relationship between such a bird as *Trogon puella* and *Geococcyx californianus* for instance. Surely there must be a gap of no mean width when we come to push them in that direction. Not long ago I published (Proc. Zool. Soc. for 1887) some contributions to the anatomy of *Geococcyx*, wherein, in my conclusions, I pointed out what appeared to be the correct classification of the United States Cuckoos, supporting Garrod's original suggestion of placing the true Cuckoos and Ground-Cuckoos in separate subfamilies. Still maintaining, as I do, this opinion, I am free to confess that I consider the subfamilies to be thus represented *markedly distinct*, to say the least of it. For instance, how close to such a bird as *Coccyzus minor* may *Geococcyx* be? Notwithstanding the zygodactyle foot in the latter (a character sometimes of uncertain meaning), I have always entertained the notion that some day we may see an affinity between *Geococcyx* and the *Dacelonināe*, as in *Dacelo gigantea*; or, carrying it a little further, a certain kinship with the *Galbulidæ*, more particularly those which possess the two carotid arteries and the myological formula A . XY. But here, again, the proper material has never yet been at my disposal.

Since the appearance of my first contribution to the present subject (P. Z. S. 1885), nothing has arisen in the course of my more extended researches which has in any way modified my original opinion in regard to the Caprimulgine birds, nor have I anything to add to what I have already stated in the body of the present memoir. They constitute the first group which I propose to remove from the old Order PICARIÆ, and for them I create a separate Order, the CAPRIMULGI, first alluded to in my previous paper, to contain all the true Caprimulgine birds of the world, including such types as *Steatornis*, *Podargus*, *Ægotheles*, *Nyctidromus*, *Nyctibius*, *Psalurus*, and others.

These birds have their nearest kin in the Owls, and they have no special affinity with the Cypseli, much less with the Trochili. With our present knowledge of their structure, these Caprimulgine forms may easily be relegated within this Order to their proper family and subfamily positions, and in a way, too, I think, that would meet the approval of all, as it would be based entirely upon the structural characteristics of the several and respective types, the best and only guide in such matters.

Coming now to the *Hirundinidæ*, I see in these fissirostral Oscinine Passeres a group of birds, which, although they still possess in their organization a majority of the structural characters of the original Passerine stock, have long since deviated from the latter. They are true Passeres considerably modified, which modifications in several instances may be traced to the adoption of new habits, and are really physiological adaptations of structure.

For instance, through ages of time they no doubt have gradually attained their increase of size in the gape, which enables them to take insect prey upon the wing with greater certainty and ease, and at the present time constitutes one of their best distinctional characters.

Whatever may be the physical principle involved that seems to demand a brevity of the brachium to suit their flight, we certainly can now perceive that a proportional shortening of the humerus is going on. Their flight, however, is not of such a vigorous nature as yet to demand much increase in the size of their pectoral muscles, and the consequent deepening of the carina of the sternum for their due attachment, nor the unnotched body of that bone to afford a more stable surface for the origin of those muscles. But with the present configuration of the countries they inhabit, and where their food is now to be had in abundance, no doubt they will long retain their present habits, and consequently their present structural organization.

Suppose, however, at some time in the world's history, ages ago, there were certain large areas inhabited by the original Hirundine stock, sufficiently differentiated from the existing Passerine types, in which from some cause there was a diminished supply of natural food—the insects which they had been accustomed to take on the wing. This would at once seem to demand in the organization of the Swallows an increased *rapidity of flight*, in order to secure for themselves and their young sufficient food during the course of the day. It would also lead, perhaps, to an increase in the size of the mouth, that this food might be captured with greater certainty. Further, they would probably be obliged to remain longer upon the wing. Continued for a sufficient length of time, such causes would be sure to work structural changes in the economy of these birds, and modifications would in consequence follow in their *wing-structure*, in the size and strength of their pectoral muscles, with an increase of the bony surface of the sternum, both in body and carina, from which these latter muscles arise; and finally, among certain other minor changes, we might find in consequence of the last-named requirement a suppression of parts in the *feet* and certain muscles of the *pelvic limb*, as the owners would now rarely perch or walk.

And this is the way, I suspect, that certain forms which we now see in our modern Swifts were differentiated from the early Hirundine stock. That this occurred early in the chapter of avian life-history, for the world is old, may be conjectured from the fact that Cypseli are now quite cosmopolitan birds, and, moreover, have many representatives among them which present highly specialized organization. Even at the present time, however, we yet have forms that structurally are nearer the Swallows than others of the same group. To instance this, we have but to glance at two such birds as *Micropus melanoleucus* and *Chætura pelagica*, in the first of which we still find the general Swallow-like form of the body, the average depth of the carina of the sternum, the non-pneumatic humerus, and other points, all of which are far more Cypseline in character in the latter bird. *Chætura*, too, agreeing with other spine-tail Swifts, shows its greater fixedness of characters in the very structures which gives it its name, for the spines which terminate its rectrices are useful to the bird, yet can only have been developed through ages of time. When we come to examine the still more Swallow-like Swifts, *Hemiprogne* for example, and its allies, I am sure we shall meet with other points in their anatomy which will lend support to this view of the origin of these types.

In the present memoir I have, by extensive and careful comparative investigations into structure, attempted to point out how entirely different these Swifts are from the Humming-birds, a group with which they have long been associated, to my mind upon very meagre claims. During the course of my present researches I have shown that Cypseli differ from Trochili, (1) in their habits; (2) in their nidification; (3) in the method of securing their food; (4) in all their external characters, and markedly in their external form; (5) in their pterylosis; (6) fundamentally in their skeletons; (7) every structure in their heads is as widely at variance as any two forms of birds in the Class; (8) in their wing-structures; (9) in their pelvic limbs; (10) in their respiratory apparatus; (11) in their visceral anatomy; and (12) in their digestive system. These two groups have been associated together upon an entirely false system of classification, which assumed first, that they are alike in their wing-structure—a resemblance which I have shown to be purely *superficial*; secondly, that they both have an unnotched sternum, although physiological law demands it, and when associated with an entire organization that widely differs from that of another form which may happen to possess an unnotched sternum, it means nothing so far as affinity is concerned. This becomes the more evident when the sterna themselves are fashioned upon essentially different plans, as is the case in the Cypseli and Trochili.

Truly related organizations *never* exhibit such an array of inharmoniously associated sets of morphological characters. And it is to the detriment of comparative anatomy, and all we may hope to effect by it, to summon to our aid such characters as "shortness" (in the case of the humeri), as "presence" or "absence" of parts (as intestinal cæcæ), and other matters of purely physical or arithmetical interest, unless there can be shown in connection therewith actual similarity in form and arrangement of parts.

Now in my first memoir (Proc. Zool. Soc. 1885) upon this subject, I proposed that in the Passeres the Cypseli should be placed next to the *Hirundinidæ*; for convinced, as I was, of their relationship, I for the moment did not take into account the artificial boundary lines of orders, genera, and what not, demanded on the part of systematists, simply having in my mind (after working many weeks over their several structures) their affinities, and not how they really ought to figure in print.

Evidently this will not do, and we must assign them some position in the system which they can occupy with propriety in ornithological works, even if it does a little violence to the delicate and intricate kinships, which the morphologist can so often see with his mind's eye, but which sometimes look so startling in type.

There is but one way at present open to us to effect this, and that is, all the true Swifts in the world must have a group or an order created for them, as the order CYPSELI, which I now propose for their reception. This Order, were it represented by a circle, would be found just outside the enormous Passerine circle, but tangent to a point in its periphery opposite the Swallows, which latter are to be found just over the line of the arc.

For the TROCHILI I have already proposed a separate order in a former communication, and am to-day more convinced than ever of the correctness of that proposal.

The time may arrive when we shall see more clearly the relationship to other groups of birds of these markedly modified and highly interesting little forms, but in the meantime a very great amount of painstaking dissections upon avian types will have to be successfully undertaken. Agreeing with the Psittaci in this particular, I am inclined to believe that the order TROCHILI will be found to be an unusually well-circumscribed one, containing upwards of 500 species, to represent it.

Since completing the main part of this paper, and especially since closing the list of acknowledgments at its commencement, I have received many kind letters relative to the work from fellow labourers in the same fields, and in some cases valuable material for comparison.

Chief among these it gives me great pleasure to thank Professor W. K. Parker, F.R.S., for many timely hints upon avian relationships, and for his ready encouragement of my work during the time it has been in progress. I am grateful, too, to Sir Edward Newton, C.M.G., formerly of the Colonial Office, of Kingston, Jamaica, for his efforts to secure me specimens of *Hemiprogne zonatus*; to Lieut. Edgar A. Mearns, of the Medical Corps of the United States Army, for specimens of Humming-birds from Arizona; to Mr. Robert Ridgway for having directed that the entire collection of birds in alcohol at the Smithsonian Institution should be gone over with the view of filling up gaps in my desiderata, although at that time it was found that no specimens in alcohol of the Macrochires were in the collections of that Institution; and finally, to Mr. F. Stephens, of San Bernardino, California, for the loan of many valuable sterna of American Trochili, from his private collections.

EXPLANATION OF THE PLATES.

(All the figures in the Plates were drawn by the Author from the specimens.)

PLATE XVII.

The pterylosis of *Ampelis cedrorum*.

Fig. 1. *a*. Ventral aspect. *b*. Dorsal aspect. Considerably reduced.

2. Muscles of the patagium of the right wing in *Ampelis cedrorum*, seen upon the outer aspect, and × 2. *tp. l*, tensor patagii longus; *tp. b*, tensor patagii brevis; *dt. p*, dermo-tensor patagii; *d*, deltoid; *t*, triceps; *b*, biceps; *e. m. r. l*, extensor metacarpi radialis longus; *h*, humerus; *u*, ulna.

3. Right lateral view of the skull of *Tyrannus verticalis*, ♂; life-size. *l*, the free lacrymal bone.

4. Same view of the skull of *Ampelis cedrorum*, ♂; life-size: letters the same.

5. Same view of the skull of *Hesperocichla nævia*, ♂; life-size.

Fig. 6. Under view of the skull of *Ampelis cedrorum*, ♂; × 2. *pmx*, premaxillary; *mx. p*, maxillo-palatine; *pp*. pars plana; *pt*, pterygoid; *ju*, jugal; *q*, quadrate; 8, foramen for vagus nerve; 9, for the hypoglossal nerve; *i. c*, for the internal carotid; *q. j*, quadrato-jugal, *eu*, Eustachian tube; *pl*, palatine; *mx*, maxillary; *v*, vomer.

PLATE XVIII.

Fig. 7. Pelvis of *Ampelis cedrorum*, × 2; dorsal aspect.

8. Basal view of the skull of *Trogon mexicanus*, × 2; the mandible removed. Lettering as in the preceding Plates, with *n. s*, nasal septum; * calls attention to the basipterygoid process of the right side.

9. Anterior aspect of the body of *Antrostomus vociferus*, to show the pterylosis. Somewhat reduced.

10. The same, shown from behind.

PLATE XIX.

Fig. 11. Superior aspect of the skull of *Trogon mexicanus*; life-size, with mandible removed.

12. Ventral or anterior aspect of the sternum of the same species; life-size.

13. Right lateral view of the skeleton of the same; life-size, with the ribs of the left side removed.

14. Dorsal aspect of the pelvis of the same; natural size.

PLATE XX.

Fig. 15. Left lateral view of the skull of *Phalænoptilus Nuttalli*, × 2. Collected by the author at Fort Wingate, N. Mexico. Lettering of the parts as on Plate XVII.

16. The same skull seen from above, × 2; mandible removed.

17. The same skull viewed upon its basal aspect; mandible removed; × 2.

PLATE XXI.

Fig. 18. Right lateral view of the skull of a specimen of *Progne subis*, ♀; × 2. Lettering of the parts as before.

19. The same skull seen from above, × 2; mandible removed.

20. The same skull viewed upon basal aspect, × 2; mandible removed.

21. Basal aspect of the skull of *Chelidon erythrogaster*, ♂, × 2; mandible removed.

22. Superior view of the skull of *Micropus melanoleucus*, ♂, × 2; mandible removed: and letters as before. This drawing is made from the same skull as the one from which I drew the basal view in a former memoir on the *Macrochires* (P. Z. S. 1885, p. 899, fig. D).

23. Superior view of the skull of *Chelidon erythrogaster*, ♂, × 2; mandible removed: letters as before. This is the upper view of the skull shown in figure 21; and *x* directs attention to the thinning of the bone in the triangular area on either side, between the nasal, frontal, and premaxillary; in the Swift (fig. 22) this entire triangular area becomes completely perforate.

PLATE XXII.

Fig. 24. Right lateral view of the skull of *Micropus melanoleucus*, ♂; × 2. Lettering of parts as before. This is the same specimen from which I drew the basal view in a former memoir on the *Macrochires* (P. Z. S. 1885, p. 899, fig. D).

25. Right lateral view (× 2) of the skull of *Tachycineta thalassina*, ♂. Lettering of parts as before.

26. Superior view (× 2) of the skull of *Tachycineta thalassina*, ♂; mandible removed. This figure and figure 25 refer to the same specimen from which I drew the figure in my former memoir (P. Z. S. 1885, p. 899, fig. F).

27. Right lateral view of the skull and mandible of *Trochilus rufus*, adult ♂; × 4. Same lettering as before.

28. Outer aspect of the muscles of the right arm in *Trochilus platycercus*. Very much enlarged. *t*, triceps; *tp. b*, tensor patagii brevis; *tp. l*, tensor patagii longus; *e. m. r. l*, extensor metacarpi radialis longus; *tn*, a tendon to the tensor patagii brevis.

29. Outer aspect of the muscles of the right arm in *Chætura pelagica*. Enlarged rather more than twice. Lettering same as in fig. 28. This figure and the last were drawn by the author directly from his own dissections.

PLATE XXIII.

Fig. 30. Ventral aspect of the pelvis of *Micropus melanoleucus*, × 2.

31. Ventral aspect of the pelvis of *Trochilus rufus*, × 3½.

32. Right lateral view, life-size, of a day-or-two-old nestling of *Trochilus Calliope*.

33. Anterior aspect of the trachea of *Trochilus rufus*, × 4½.

34. Digestive tract of *Trochilus platycercus*, × 2½.

35. Anterior aspect of *Trochilus Calliope*, adult, with the chest-wall and other parts removed to show the relative size and position of organs. *l. c*, left carotid; *H*, heart; *r. l*, right lobe of liver; *l. l*, left lobe of liver. × 2½.

36. Same view and similar dissection of *Micropus melanoleucus*. *S*, stomach, with other lettering as in figure 35. Somewhat enlarged.

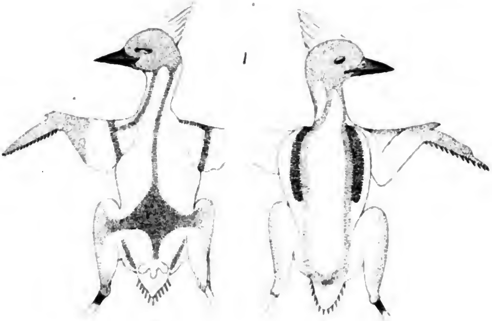
PLATE XXIV.

Fig. 37. Left lateral view of a plucked specimen of *Micropus melanoleucus*.

38. The same of *Chætura pelagica*.

39. The same of *Trochilus platycercus*.

These are all life-size figures of male birds obtained by careful contour traces directly from the bodies of the specimens, and are not intended to show any part of the pterylography.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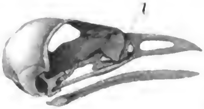
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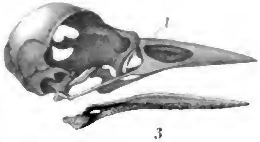
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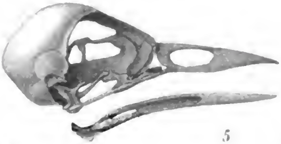
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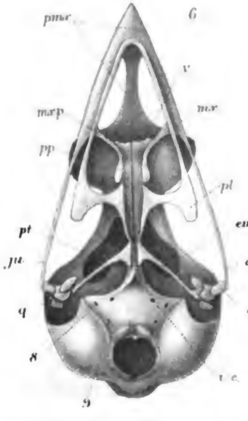
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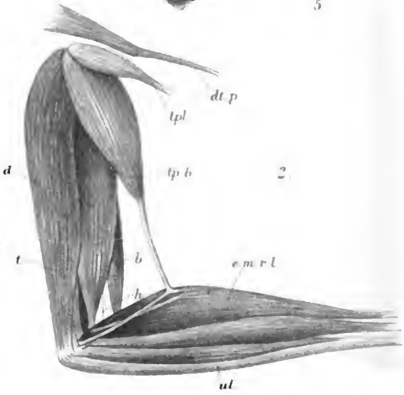
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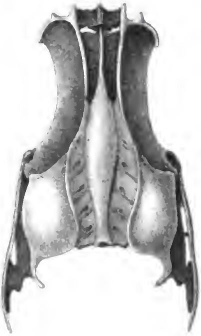

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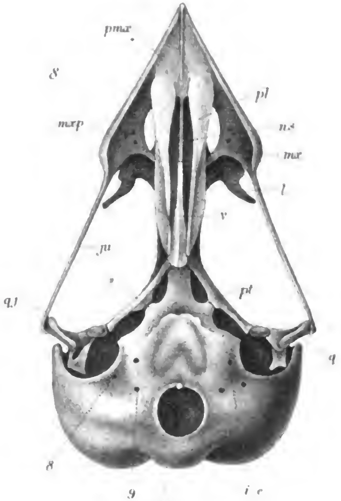

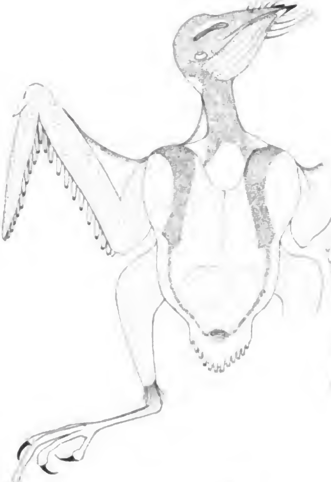

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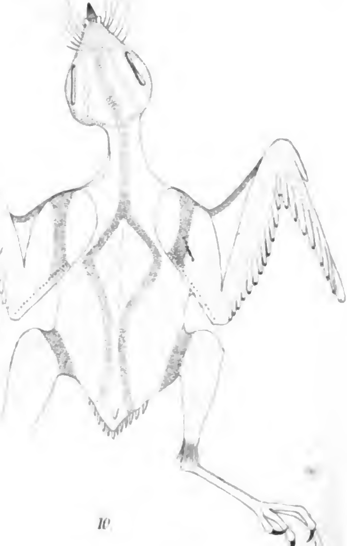

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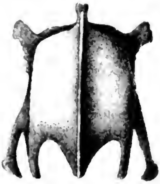

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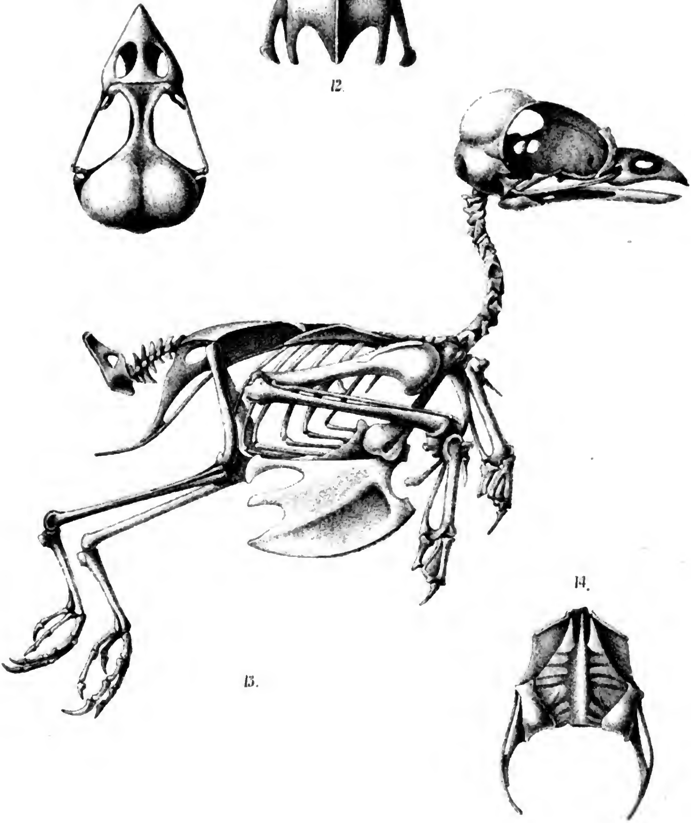

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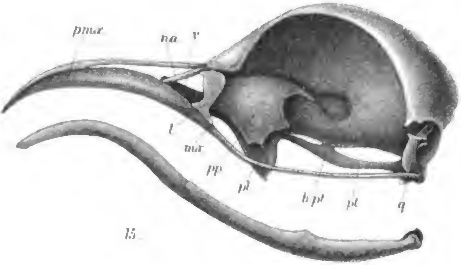

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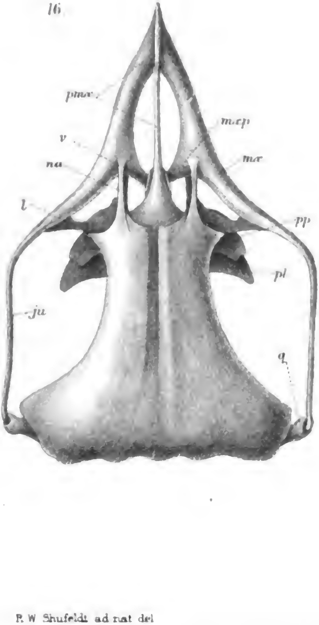

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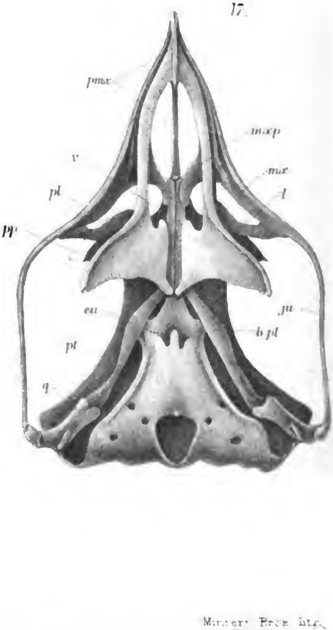

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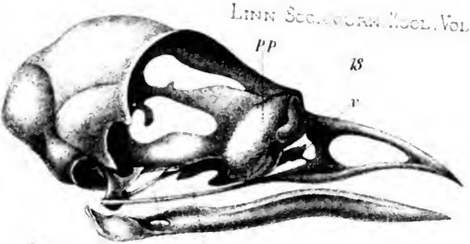

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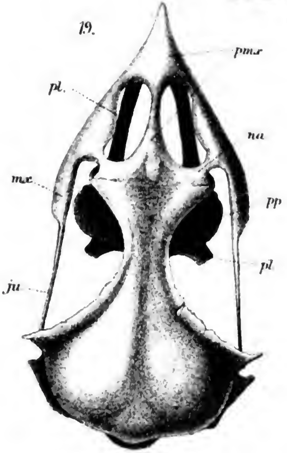

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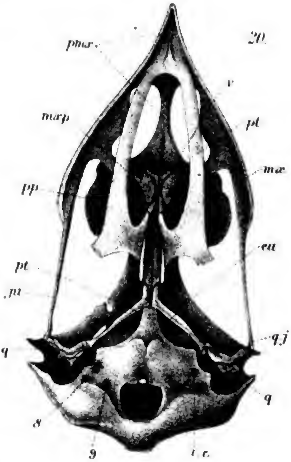

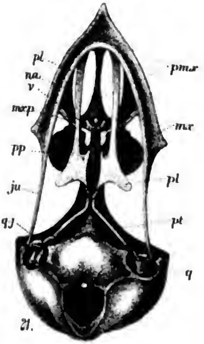

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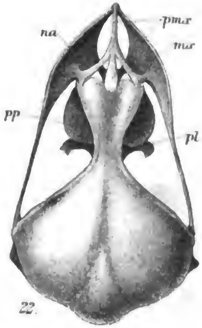

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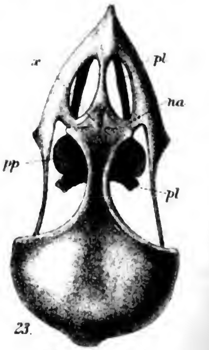

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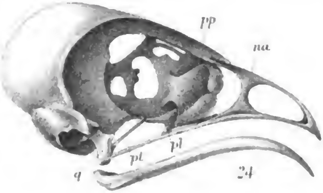

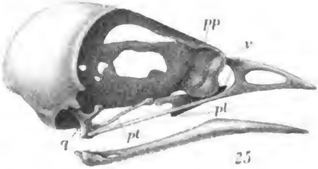

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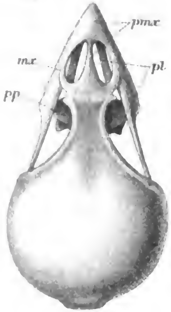

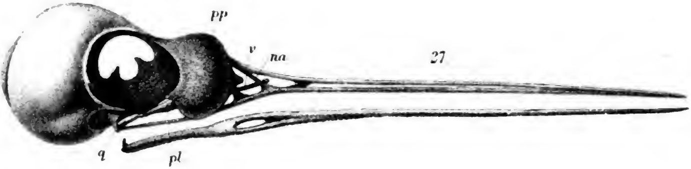

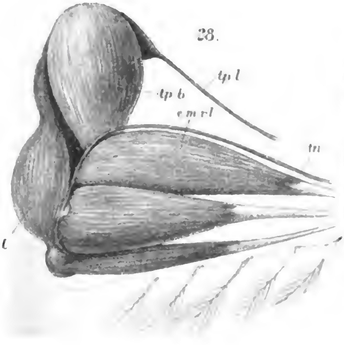

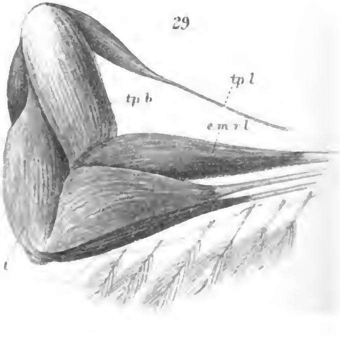

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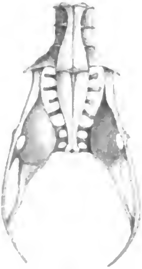

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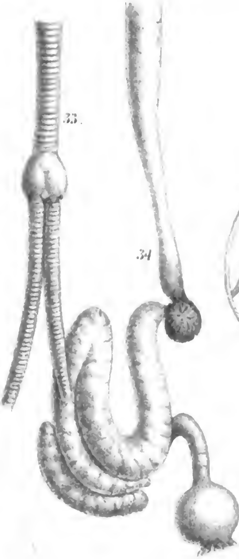

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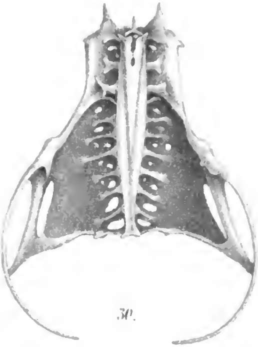

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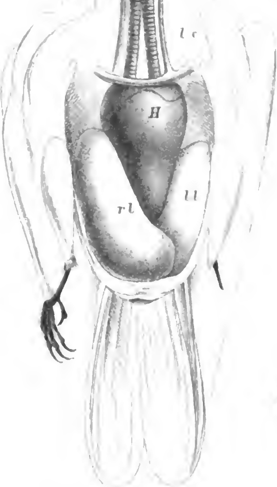

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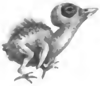

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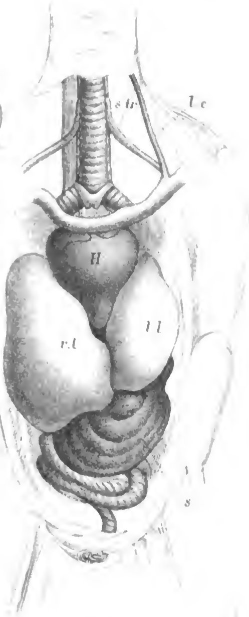
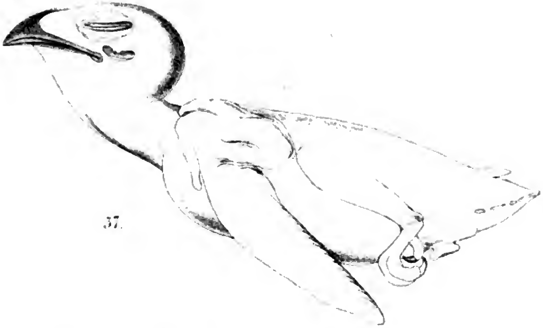


36.

R. W. Shufeldt ad nat. del.

STUDIES OF THE MACROCHIRES.

Mintern Bros. lith.



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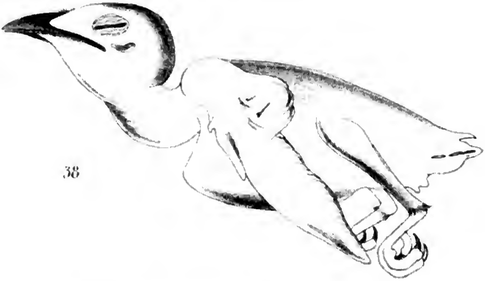

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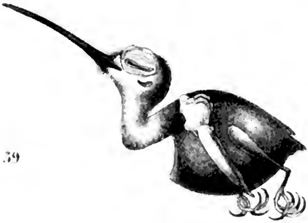


39.

R. W. Shufeldt ad nat. del. Mintern Bros. lith.

STUDIES OF THE MACROCHIRES.

Descriptions of fourteen new Species of Shells.

By G. B. Sowerby, F.L.S., F.Z.S.

[Read 20th December, 1888.]

(Plate XXV.)

Pleurotoma (Mangelia) Brionæ, sp. nov. (Pl. XXV. figs. 14, 15.)

Testa elongata, anguste turrita, pallide fulva, transversim obscurissime fusco multi-lineata; anfractus 9, convexi, spiraliter minutissime densissime striati, longitudinaliter costati, sutura impressa sejuncti; anfractus ultimus parviusculus, leviter convexus, costis 10 elevatis lævigatis munitus, ad basin acuminatus, vix productus; apertura oblonga, mediocriter lata, utrinque angustior; columella rectiuscula; labrum arcuatum, postice paulo sinuatum.

Long. 20, maj. diam. 6 millim.; apert. long. 7½, maj. lat. 2½ millim.

Hab. Hongkong.

This species somewhat resembles an elongated form of the British *P. nebula*, but is considerably larger, and distinguishable by a very long and turreted spire. The shell is apparently smooth, and the very fine spiral striæ can only be seen through a lens. The longitudinal ribs are rounded and smooth. Only one perfect specimen was brought by Dr. Hungerford from Hongkong.

Oliva Bülowi, sp. nov. (Pl. XXV. fig. 3.)

Testa subcylindraceo-fusiformis, lutea, obscure griseo nebulata, antice conspicue rufo-fusco flammata; spira acuminata; anfractus 7, planato declives, griseo-fusco obscure fasciati, sutura canaliculata sejuncti; anfractus ultimus supra medium obscure angulatus, infra medium flammis rufo-fuscis obliquis peculiariter pictus; columella rectiuscula, 7-plicata, basi contorta, albo callosa, unisulcata; apertura modica, antice paulo latior, intus albida; labrum fere rectum, leviter complanatum.

Long. 32, maj. diam. 13 millim.

Hab. New Britain.

This shell resembles *O. emicator* (Meusch.) in form, but the colouring is very peculiar and characteristic, with conspicuous reddish-brown flames only on the lower part of the body-whorl. The type specimen is in the collection of Mr. Carl Bülow in Berlin, and is the largest I have seen; the smallest is about 20 millim., and the average length is about 26 millim.

Mitra formosensis, sp. nov. (Pl. XXV. figs. 4, 5.)

Testa fusiformis, fusca, albo-fasciata; spira elongata, acuta; anfractus 11, leviter convexi, sutura impressa sejuncti, albo unifasciati, primi 8–9 longitudinaliter costellati, spiraliter multisulcati, deinde spiraliter striati, haud costellati; anfractus ultimus spiram subæquans, rotunde con-

vexus, fascia alba supra et infra medium ornatus, infra medium valde contractus, in cauda brevi desinens, spiraliter liratus; columella quinqueplicata; apertura intus albida; labrum crassiusculum, læve, nigro-fusco limbatum.

Long. 50, maj. diam. 16 millim.; apert. long. 24, lat. 4½ millim.

Hab. Island of Formosa.

A species belonging to the "*Turricula*" section, somewhat resembling *M. caffra*, but with the whorls more rounded and the body-whorl much shorter in proportion to the spire, rounded in the middle and contracted at the base. Three specimens from the Island of Formosa, all similarly marked, and differing but little in form.

Mitra recurva, sp. nov. (Pl. XXV. fig. 7.)

Testa fusiformis, alba, fusco-maculata; spira acutissima, mucronata, subgradata; anfractus 10, superne angulati, deinde levissime convexi, longitudinaliter costati; costis numerosis, lævigatis, rotundatis, ad angulum tuberculatis, interstitiis transversim sulcatis; anfractus ultimus spiram leviter superans, infra medium multo et abrupte attenuatus, in cauda recurvata desinens; columella sinuosa, quinque-plicata, superne tuberculo albo rotundato munita; apertura longa, antice angustata, intus fusco-maculata; labrum arcuatum, tenue, pellucidum.

Long. 16, maj. diam. 6 millim.

Hab. Mauritius (*V. de Robillard*).

A very pretty little species, with a prolonged recurved canal. The longitudinal ribs are neatly tubercled at the suture, the interstices transversely grooved, and the turreted spire produced and attenuated towards the apex. The brown blotches are for the most part arranged in two zones above and below the middle of the body-whorl.

Mitra Smithi, sp. nov. (Pl. XXV. fig. 6.)

Testa elongato-fusiformis, albida, fulvo fuscoque sparsim fasciata et maculata; spira acutissima, mucronata, subgradata; anfractus 11, convexiusculi, longitudinaliter costellati; costellis numerosissimis, angustis, confertis, rotundatis, lævigatis, juxta suturam tuberculatis, insterstitiis haud striatis; anfractus ultimus spiram æquans, supra et infra fascia pallide fulva fusco maculata picta, zona media albida, infra medium attenuatus, spiraliter sulcatus et granulatus, in cauda recurvata desinens; columella leviter sinuosa, triplicata, plicis crassiusculis; apertura longa, angusta.

Long. 16, maj. diam. 5 millim.

Hab. Mauritius (*V. de Robillard*).

Another elegant little species, in several respects similar to the last, but much narrower and more cylindrical in form; the ribs

much closer, and the interstices not grooved. The colouring and form of the apex, as well as of the canal, are curiously similar, as also the beading at the top of the ribs.

OVULUM (BIROSTRA) HAYNESI, sp. nov. (Pl. XXV. figs. 1, 2.)

Testa elongata, angustata, albida, polita, utrinque rostrata, postice attenuata, antice subtruncato-acuminata, extremitatibus acutiusculis, lateribus leviter convexis; apertura medio angustissima, postice paulo latior, antice dilatata; columella convexa, nitidissima, labrum incrassatum, leviter sinuosum.

Long. 34, maj. diam. 7 millim.; apert. maj. lat. 2½, min. vix 1 millim.

Hab. Exmouth Gulf, W. Australia (*J. H. Haynes*).

A graceful species allied to *O. Philippinarum*, but larger and differing in form.

The specimens are nearly white, being found attached to a very handsome white species of *Melitodes*, which is also probably new to science, and of which Mr. Haynes collected several specimens in the above-named locality, one of which he presented to the Natural History Museum at South Kensington. The colour of *Ovulum* is probably determined by that of the place of attachment, as is the case with several well-known species which occur on West-Indian Gorgoniæ, so that should specimens be found attached to *Melitodes ochracea* (of which Mr. Haynes found several in the same locality) they would probably be of an orange colour. Hitherto, however, they have only been found on the white species.

TROCHUS (INFUNDIBULUM) BACCATUS, sp. nov. (Pl. XXV. figs. 8, 9.)

Testa breviter conica, late umbilicata, luteo-albida, nigro fuscoque punctata; anfractus 6, convexiusculi, spiraliter striati et granulis gemmuliformibus nigro-fuscis, fulvis et albidis quinqueseriatim dispositis instructi; anfractus ultimus ad peripheriam angulatus, infra planato-convexus, liris 6, angustis, parum elevatis, fusco articulatis ornatus; apertura obliqua; columella oblique rectiuscula.

Alt. 12, maj. diam. 14 millim.

Hab. Mauritius.

A pretty little species, regularly and exquisitely spotted and beaded.

THALOTIA WILKIÆ, sp. nov. (Pl. XXV. figs. 10, 11.)

Testa conica, elata, grisea, albo fuscoque maculata et strigata; apice fusco; anfractus 7, planato-declives, ad suturam undulatim angulati, spiraliter multi-lirati, liris rugosis, hic illic irregulariter nodulosis; anfractus ultimus inferne angulatus ad basin levissime convexus, angus-

tissime umbilicatus, spiraliter liratus, liris 8 (lira minima interveniente) rugosiusculis; columella leviter sinuata, lævigata; apertura subquadrata, intus argentea.

Alt. 19, maj. diam. 15 millim.

A single specimen, locality unknown.

Amathina imbricata, sp. nov. (Pl. XXV. figs. 12, 13.)

Testa elongato-subtrigona, inæquilatera, sordide alba, utrinque angulata, postice incurvata; dorso leviter concavo, laminis rugosis transversis partim tubulosis sculpto, margine sinistrali bicarinato, dextrali unicarinato, lateribus corrugatis, dextra concava, sinistra planulata; apice minutissimo; apertura oblonga, antice quadrata, postice rotundata.

Long 13, maj. diam. 7, maj. alt. 5 millim.

Hab. Mauritius.

This species differs from the type (*Amathina tricarinata*) in several particulars. Of the three keels, two are close together on the left dorsal margin, and the broad space between these and the right keel is curiously laminated and corrugated. A single specimen of this interesting shell has been sent me from Mauritius by M. V. de Robillard.

Cochlostyla (Axina) Gloynei, sp. nov. (Pl. XXV. figs. 16, 17.)

Testa globoso-depressa, imperforata, solidiuscula, nigro-fusca, ad apicem pallida, epidermide albida hydrophana, in strigis obliquis et fasciis transversis dispositis pulcherrime ornata; spira convexa, apice obtusa; anfractus 6, convexiusculi, lente accrescentes, oblique striati, sutura impressa sejuncti; anfractus ultimus subinflatus ad peripheriam obscurissime angulatus, superne et inferne convexus; columella brevissima, albida, oblique recta; apertura parviuscula, transverse oblonga, leviter arcuata, ubique subæqualiter lata, intus purpurea; labrum arcuatum, tenuiter reflexum, leviter complanatum, purpureum, fusco limbatum.

Maj. diam. 33, alt. 24 millim.; apert. long. 15, lat. 6 millim.

Hab. Philippine Islands.

A single specimen, in perfect condition, of this interesting shell is in the collection of Mr. C. P. Gloyne. The whitish diaphanous epidermis in oblique streaks and transverse bands relieves the plain dark-brown colour of the shell, which, though not particularly remarkable in form, differs considerably from its congeners.

Orthalicus MacAndrewi, sp. nov. (Pl. XXV. fig. 18.)

Testa elongata, griseo-fulva, fusco zonata et strigata, hic illic nigro radiata; apice obtusiuscula, griseo-lilacea; anfractus 8½, regulariter accrescentes, convexiusculi, longitudinaliter leviter striati, sutura impressa

sejuncti, lineis 3 vix conspicuis fusco alboque articulatis (in anfr. postpenult. evanidis) spiraliter notati; anfractus ultimus spiram subæquans, rotunde convexus, zona supra griseo-fulva, media et infra fusca; columella fere recta, tenuicula, intus griseo-lilacea, extus nigra; apertura semiovalis, intus lilacea; peristoma simplex, haud reflexum, vix incrassatum, nigro limbatum, margine columellari callo nigro late interne suffuso induto.

Long. 70, maj. diam. 30 millim.; apert. long. 28, maj. lat. 16 millim.

Hab. Santiago de Cou, Peru.

This species, of which I have only seen a single specimen, is similar in form to *O. Bensoni*, but it has no spiral sculpture and the colouring consists principally of light brown zones with a few longitudinal streaks of brown and black; the articulated painting is very slight, and is only to be seen on the upper whorls.

PECTUNCULUS CREBRELIRATUS, sp. nov. (Pl. XXV. fig. 20.)

Testa transverse ovata, crassa, subæquilateralis, albida, fusco hic illic sparsim maculata et fasciata, costis circ. 30, parum elevatis, et liris numerosissimis angustissimis radiata, striis concentricis cancellata, minutissime granulata; umbones prominentes; area ligamenti recta angustiuscula, mediocriter longa; latere antico rotunde arcuato, postico angulato; margo dorsalis posticus declivis; cardine arcuato, dentibus numerosis divergentibus instructo, pagina interne alba, postice fusco tincta.

Long. 35, umbonis marg. 31 millim.

Hab. Moreton Bay, Australia.

Resembling *Pectunculus angulatus* in form, but quite differently sculptured. It is densely radiately ridged throughout and sculptured with minute transverse striæ, which give a rough granular character to the surface. The epidermis remaining on the margin of the shell is velvety.

CRASSATELLA JAPONICA, sp. nov. (Pl. XXV. fig. 19.)

Testa ovato-trigona, crassa, inæquilateralis, fulva, fusco radiata, concentrice irregulariter striata; umbones acuti, approximati; area dorsalis utrinque mediocriter excavata; latere antico rotunde arcuato, postico biangulato; margo dorsalis posticus recto-declivis; pagina interna carnea, impressiones musculares fulvo imbutæ.

Long. 32, umbonis marg. 27 millim.

Hab. Japan.

A very distinct species, though presenting no very prominent characters. The style of radiation is common to many of the *Crassatellæ*, but the rough irregular striation in place of the ordinary concentric grooves is peculiar.

Clavagella minima, sp. nov. (Pl. XXV. figs. 21, 22.)

Testa parva, alba; tuba longitudinaliter compressa, apertura leviter reflexa, haud fimbriata; valva dextra lata, planulata, extus concentrice irregulariter rugata, intus argentea, margo dorsalis fere rectus, ventralis valde arcuatus.

Valvæ, umbonis marg. 7, antero-post. 10 millim.

Hab. Mauritius (*V. de Robillard*).

This small Mauritian species is certainly distinct from the Maltese *C. aperta*, but it is impossible to say whether the specimens are full-grown or not. I have seen four specimens differing but little in size, two of which are in the National Collection at South Kensington.

DESCRIPTION OF PLATE XXV.

Fig. 1, 2. *Ovulum Haynesi*, p. 397.
3. *Oliva Bülowi*, p. 395.
4, 5. *Mitra formosensis*, p. 395.
6. —— *Smithi*, p. 396.
7. —— *recurva*, p. 396.
8, 9. *Trochus baccatus*, p. 397.
10, 11. *Thalotia Wilkiæ*, p. 397.
12, 13. *Amathina imbricata*, p. 398.
14, 15. *Pleurotoma Brionæ*, p. 395.
Fig. 16, 17. *Cochlostyla Gloynei*, p. 398.
18. *Orthalicus MacAndrewi*, p. 398.
19. *Crassatella japonica*, p. 399.
20. *Pectunculus crebreliratus*, p. 399.
21, 22. *Clavagella minima*, p. 400.

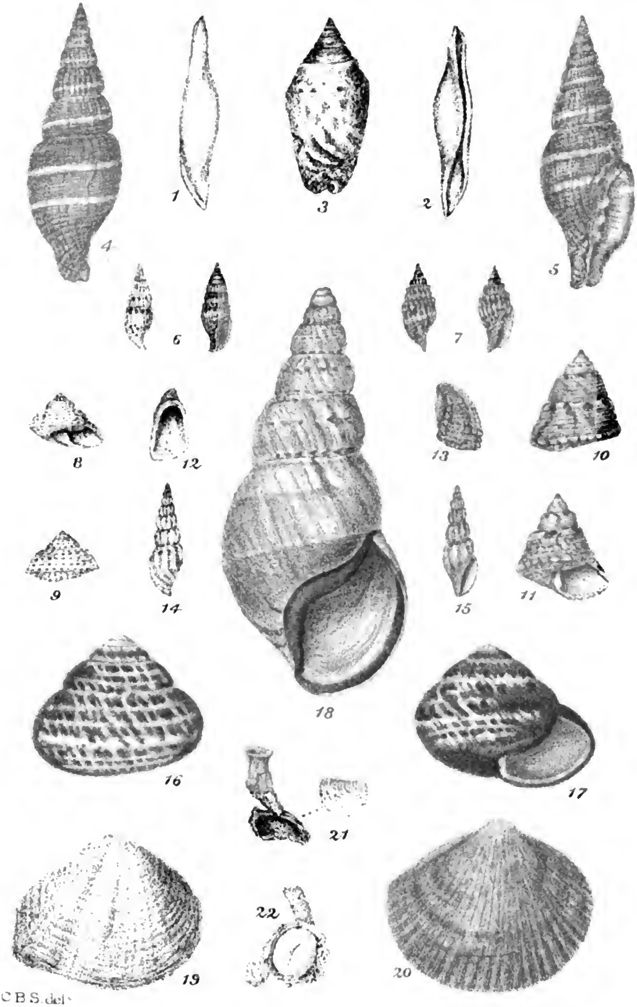
On some unrecorded Parasitic Acari found in Great Britain.

By A. D. Michael, F.L.S., F.Z.S., F.R.M.S.

[Read 7th February, 1889.]

(Plate XXVI.)

I spent the summer of 1888 in Derbyshire, near Chatsworth: the cold and wet season, however, rendered ordinary open-air collecting very fruitless; I therefore took the opportunity of obtaining all the wild mammals which I could obtain alive, or immediately after death, with a view to see whether I could find any unknown forms of parasitic *Acari*. My search was rewarded by finding the three species recorded in this paper, which, I believe, were not previously known. The *Myocoptes* adds another to this curious genus, which was founded by Claparède, and of which there was only one species known previously; both are parasites of the mouse and rat tribe; they are strictly ecto-



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NEW SHELLS.

parasitic, living among the hairs, and they are furnished with the most remarkable apparatus for holding these hairs, to which the females of the present species cling so tenaciously that the grasp is often not relaxed even in death. The species now described is very much smaller than that previously known.

The second species is a *Symbiotes*, one of the Sarcoptidæ, and is a parasite of the hedgehog. I regret that I was not able to find the male of this species; but I only had one hedgehog, the parasites were extremely few upon it, and these few were most difficult to catch, running up and down the quills of the hedgehog and about between them with great rapidity.

The third species, which is very minute, does not appear to fit satisfactorily into any known genus; I have therefore been forced to institute a genus, "*Goniomerus*," for it; the species will of course serve as a type for the genus; it would be too soon to attempt to define the latter accurately in any other manner, particularly as the present species is so extremely minute as to render detailed observations of it most difficult.

MYOCOPTES TENAX, n. sp. (Pl. XXVI. figs. 1–7.)

	Male. mm.	Female. mm.
Length about	·15	·20 to ·27
Breadth about	·11	·10
Length of 1st and 2nd legs, without the claws, about	·06	·06
Length of claw of 2nd leg	·03	·02
Length of 3rd leg, without claw	·04	·04
Length of claw of 3rd leg	·03	·02

The colour and texture in both sexes is very similar to that of the only other known species of the genus, viz. *M. musculinus*, except as mentioned below.

Male.—Diamond-shaped, the division between the cephalothorax and abdomen well marked by a nearly straight transverse line, the body being slightly constricted at this point. Outline of cephalothorax slightly and irregularly undulated; that of the abdomen on each side convex anteriorly, then concave, and again convex posteriorly. The abdomen is not divided posteriorly into two pointed projections as in *M. musculinus*, but comes to a single central bluntish point. On each side of this point is a square projection, from each of the two outer corners of which springs a very long and powerful hair. Thus there are two pairs of these hairs instead of one pair, as in *M. musculinus.* These hairs are nearly as long as the whole length of the body; both pairs curve upwards at first, and then run backward and outward; but the pair near the centre are much the straighter. There are two other much smaller hairs springing from each of the square projections. There are two large hairs on each side of the body, one a little in front of, and one a little behind, the constriction between cephalothorax and abdomen; the hinder is considerably the larger. There is a pair of large hairs on the dorsum of the cephalothorax, and several smaller pairs on that of the abdomen. The claws of the first two pairs of legs are extremely long, very slightly curved, and rod-like. The legs of the fourth pair, although of the same general form as in *M. musculinus*, are very much smaller in proportion, they do not project behind the body, and are scarcely thicker than those of the first and second pairs; they are much shorter and narrower than those of the third pair, which extend considerably further back than the body. Each tarsus of the fourth pair bears a long flexible hair and a short stout spike still nearer to the tip. On the inside of the flattened claw of each third leg, at the proximal end of the claw, is a curved chitinous process projecting inward, and a similar process is found on the preceding joint. There are several pairs of long hairs on the ventral surface, and a pair of stout spines behind the penis.

The Female.—The female differs from *M. musculinus* more than the male does. The abdomen of the present species is almost cylindrical, although somewhat flattened dorso-ventrally; it is slightly smaller at the ends than in the middle, but is without the highly flattened form and the lateral angular projections found in the other species. The whole abdomen is covered by strong, slightly irregular transverse wrinkles or ridges; these are slightly rough, but are not set with the well-marked and regular points found on those of the female of *M. musculinus.* The length of the abdomen varies greatly in different specimens, or more probably in the same specimens at different times: there is usually one egg matured at a time, and as it is very long, it probably elongates the extensile abdomen as it grows, and other circumstances will probably produce temporary variations in the length of the abdomen. The variation in the length of the female noticed in the measurements arises almost entirely from the abdomen. The creature usually holds the hair of the mouse with the third and fourth claws, and keeps the rostrum sharply inclined downward, while the abdomen is somewhat raised; thus the creature has the appearance of possessing caput, thorax, and abdomen. The abdomen has two very long hairs at its hinder end, and there are two smaller, but still large, hairs on the lateral edge between the second and third legs; and two on the cephalothorax, as in the other species, besides two sparse longitudinal rows of smaller hairs on both divisions of the body. The first and second legs are like those of the male, but the claws are shorter. The third and fourth legs resemble the third pair of the male, but the claws again are shorter, but, on the other hand, they are broader. These great holding-claws in this species are much wider in proportion than those of *M. musculinus*; indeed, their breadth is very remarkable. On the ventral surface the epimera of the first pair of legs join in the median line and are prolonged by a short sternum (so-called); those of the second pair of legs are forked at their distal ends. Posterior to these, and almost touching those of the third pair, are two conspicuous chitinous pieces of rather more than half-a-circle shape with their outer corners slightly prolonged; the chitinous pieces protect the vulva, which lies between the third and fourth pairs of legs.

The Nymph.—The nymph is very similar in form to the male, but without the square posterior projections; there is only one pair of large hairs posteriorly. The fourth pair of legs are similar to the third, as in the female. The constriction between cephalothorax and abdomen is very marked. Neither pair of legs are nearly so long as the third pair of the male.

The Larva.—Almost diamond-shaped; of course there are not any fourth legs, but the third pair are placed near the posterior end of the body, giving a very singular appearance. Otherwise the larva resembles the nymph. Both differ considerably from those of *M. musculinus.*

Habitat. Parasitic upon the field-vole (*Arvicola agrestis*).

SYMBIOTES TRIPILIS, n. sp. (Pl. XXVI. fig. 8.)

	Female. mm.
Length about	·33
Breadth about	·26
Length of legs: 1st and 2nd pairs about	·15
3rd pair about	·06
4th pair about	·03
Length of longest hair on 3rd tarsus about	·70
" " on hind margin of body about	·40

This species is closely allied to the *Chorioptes setiferus*, var. *hyenæ* of Mégnin; there are, however, well-marked specific differences.

I have adopted Gerlach's name of *Symbiotes* for the genus in preference to Gervais's name of *Chorioptes*, which Mégnin has employed, because Gerlach's is the earlier, and Mégnin appears to have used *Chorioptes* under a misapprehension. Mégnin says that Gerlach's name has priority, but he says that it fails because Redtenbacher had already called a genus of Coleoptera by that title; this, however, seems to be an error. Gerlach's name was published in his monograph in 1857, whereas Redtenbacher's genus was in his 'Fauna Austriæ' in 1858; it is therefore the latter genus which fails, not Gerlach's.

I have, unfortunately, not been able to obtain the adult male.

Female.—Body irregularly pentagonal, broadly truncated posteriorly; considerably wider anteriorly than posteriorly; anus projecting from the hind margin. Body almost white, semitransparent; rostrum, epimera, and legs strongly chitinized and brown. First and second pairs of legs thick and strong; the tarsus of each of these legs has a strong hair or rod springing from its upper surface in the median line; this hair is of almost equal thickness throughout, and ends quite bluntly, it stands upward and is considerably longer than the tarsus. These tarsi are terminated, as usual, by suckers. The epimera of these two legs nearly join at their posterior ends. The third pair of legs are much smaller, not above half the length; they are terminated by three very long hairs of unequal lengths, the longest is more than twice the length of the body. The fourth legs resemble the third, but are so small as to appear quite rudimentary; they are not above half the length of the third pair, they also are terminated by three long hairs, but these are small and short compared with those on the third pair. The body bears two pairs of very long hairs on the hind margin, the outer hair of each pair is considerably longer than the inner, the outer hair is longer than the body. The vulva is a rounded median depression, towards which the striæ of the skin run from all sides, as in *S. setiferus*.

The Nymph.—Resembles the adult female, but, of course, is smaller and less chitinized.

Habitat. I found the species upon the hedgehog (*Erinaceus europæus*). It is very active, running up and down the spines of the hedgehog with great rapidity.

GONIOMERUS* MUSCULINUS, nov. gen. et sp. (Pl. XXVI. fig. 9.)

	mm.
Length about	·155
Breadth about	·105
Length of legs (all pairs) about	·035

Colour.—Semitransparent white.

Texture.—Much that of the ordinary Sarcoptidæ, *i. e.* smooth and leathery, not polished. The skin is marked more or less with excessively fine wrinkles or striations, so fine that they are very difficult to see.

Form &c.—Body almost oblong, but somewhat narrower posteriorly than anteriorly; there is not any clear demarcation between cephalothorax and abdomen. The rostrum projects, but is bluntish; a pair of mandibles may sometimes be seen projecting from the mouth-opening. The rostrum bears a pair of fine hairs. The body is much compressed dorso-ventrally, and is divided into four lobes on each side, the hind lobe showing a slight tendency to be bifid. On the posterior margin there is a slight indentation above the anus, which is almost terminal, but slightly on the ventral surface. From the hind margin spring a pair of long hairs directed backward, they are fully two thirds of the length of the body; immediately below them are another pair of similar hairs proceeding from lobes on the ventral surface; as this under pair is entirely concealed by the upper pair, when viewed from above, it is not shown in the figure. The legs are short, and are the great peculiarity of the creature; they are all alike and all directed forward, the fourth pair usually more so than is shown in the figure, where they are spread out. They consist of five joints; the femur is very large and singular in shape, it projects beyond the body and bends suddenly at rather less than a right angle, so as to form an advancing corner which completely alters the direction of the leg. The more distal joints become gradually smaller; the tarsus is terminated by a small claw, smaller in proportion than can be shown in a drawing the size of fig. 9, and there is another small chitinous projection close to it which may be regarded as a mere peg or a second claw; I am inclined to look on it in the former light. There are hairs on the underside of each joint of the leg and one or more on the upperside of each tarsus, besides a few others. The penis is placed on the ventral surface in the median line between the hinder part of the coxæ of the third legs; the vulva between those of the second legs.

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* γωνία, an angle; μηρὸς, the thigh.

I found the creature on the surface of, or very slightly buried in, a depression of the skin lining the inner side of the external ear of the short-tailed field-vole (*Arvicola agrestis*). I believe it to be unrecorded, and propose to call it "*Goniomerus musculinus*."

DESCRIPTION OF PLATE XXVI.

Fig. 1. *Myocoptes tenax*, ♀. Dorsal aspect. × 175. Drawn from a specimen with long abdomen.
2. " " " Ventral aspect. × 175. Drawn from a specimen with short abdomen.
3. " " " From the side. × 175. Natural position, holding the hairs of the mouse.
4. " " ♂. Dorsal aspect. × 175.
5. " " " Ventral aspect. × 175.
6. " " nymph. Dorsal aspect.
7. " " ♀. 3rd leg, seen from the inner side. × 350.
8. *Symbiotes tripilis*, ♀. Ventral aspect. × 130.
9. *Goniomerus musculinus*, ♂. Dorsal aspect. × 175. (There is another pair of long hairs on the hind margin, below and hidden by the pair shown.)

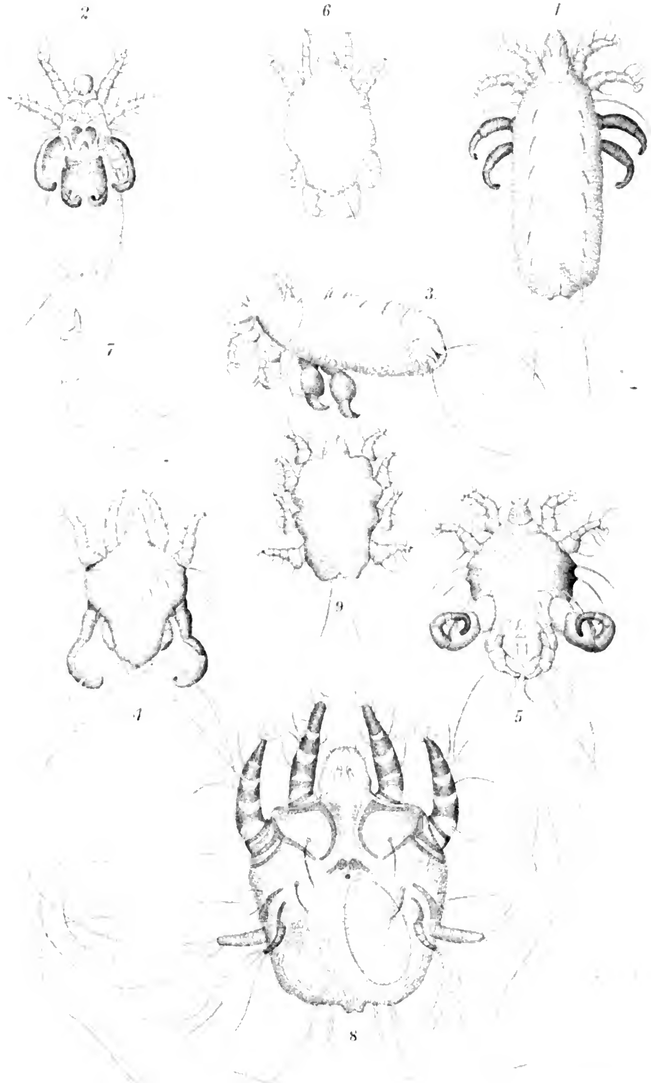
On the Structure of the Retina of the Blowfly (*Calliphora erythrocephala*). By BENJAMIN THOMPSON LOWNE, F.R.C.S., F.L.S., Hunterian Professor of Comparative Anatomy in the Royal College of Surgeons.

[Read 21st February, 1889.]

(PLATE XXVII.)

IN 1884 I had the honour of reading a paper before this Society on the compound vision and morphology of the eye in insects, which was published in the second volume of the new series of 'Transactions.'

That paper received at the time much adverse criticism, and Dr. Hickson published a memoir in the 'Quarterly Journal of Microscopical Science,' in which he convinced himself that he had completely refuted my observations.



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From that day to this I have continued to work at the subject, and I now venture to bring before this Society evidence which I think can hardly fail to convince even the most sceptical of my opponents. Although I never had any doubt of the correctness of my figures or descriptions, I felt it incumbent upon me to produce preparations which would admit of no double interpretation, but which would appeal at once to the eyes of those who are only partially acquainted with the histology of the vertebrate retina.

At the time I published my former paper I felt so certain that the views I held would receive a ready acceptance, that I did not, perhaps, enter sufficiently into minute details, and left many points to be investigated by other workers. I have since examined every structure in the greatest detail, and have much to add with regard to the developmental history of the compound eye.

The retinal rods, which I figured correctly in my former paper, correspond with the periopticon of Dr. Hickson, except that his figures show that every vestige of nerve-structure and nerve-terminal organs had been completely destroyed in his preparations, leaving nothing but the skeletal framework with the tracheal vessels, which he has delineated most carefully and correctly.

He states that my paper and investigations were unnecessary, owing to the unanimity of previous investigators: none, however, agree in any detail with Dr. Hickson, nor, so far as I am able to judge, to any considerable extent with each other.

Putting aside for the moment the earlier observers, the so-called periopticon of Hickson has only been described in detail by Berger, Carrière, Ciaccio, Viallanes, Hickson, and myself.

To show how far these observers agree with each other and with the older writers, I will quote a few sentences from Dr. Hickson's paper. He says:—

"Previous to the publication of Berger's paper the optic tract of insects had been briefly described and names given to the various regions. Thus Weismann called the opticon and epiopticon the 'bulbus,' the region where the optic fibrils decussate the 'Stiel,' and the periopticon the 'Augenscheibe'" (*l. c.* page 27).

Even the most cursory acquaintance with the work of the German naturalist would have shown Dr. Hickson that this is an egregious misstatement of Dr. Weismann's nomenclature.

Weismann's 'Stiel' was the optic nerve, and his 'Augenscheibe' the structure from which the dioptron is developed. I shall have later to give Dr. Weismann's views more fully. Dr. Hickson continues (page 27):—" Since Berger's paper appeared Carrière has described the periopticon as 'a layer of long palisade-shaped cells, the number of which corresponds with the eye units; every one of these palisade cells possesses an oblong nucleus at its foremost, somewhat broader, end.' My researches show that this description is quite inaccurate. The elements of the periopticon are not cells, and the large oval nucleus situated in each element does not exist; nerve-cells, when they exist in the region of the periopticon in *Musca*, lie between the elements and not in them, as my figures show."

These statements and others show that Dr. Hickson and Carrière do not agree. With regard to the nuclei described by Carrière, they undoubtedly exist, but not, as Carrière thought, within the palisades, but externally to them, immediately beneath their investing sheath. Dr. Hickson is right when he says these bodies are not cells, they are developed from cells, and each consists of a bundle of fusiform rods. With regard to the terminations of the optic nerve, Carrière distinctly traced the nerve-fibres into the palisades; Dr. Hickson says they go round them. I trace them directly into the fusiform rods which form the palisades. The structures seen and correctly figured by Dr. Hickson are tracheal vessels.

Carrière supposed the nerve-fibres to pass out at the superficial end of the palisades and to perforate the basilar membrane; from this I entirely dissent. In support of this view Carrière has figured, quite diagrammatically, what I believe is a tracheal vessel seen behind the fusiform body. Carrière also saw the highly refractive outer ends of the rods, or, rather, that part which is connected with their inner portion, and says, " in *Musca vomitoria* one sees in every cell a cylindrical axis."

Dr. Hickson entirely put himself in the wrong in describing the nervous elements as between the palisades; his nervous elements are undoubtedly fine tracheal tubes. Dr. Hickson's figures accurately represent the nerve-sheaths and tracheæ as well as the supporting neuroglia, but no vestige of nerve or nerve-end organs appears in them. A careful examination of his own figures at once leads to a dissent from all his statements, which are as inaccurate as his figures are accurate. I cannot understand how so good an observer could have been so misled.

Berger and Viallanes trace the optic-nerve fibres through a series of small round cells, very conspicuous in the outer half of my retina, Hickson's periopticon. Hickson regards these cells as of quite secondary import. They clearly belong to the supporting tissue and are external to the sheaths of the retinal elements, which are continuous with the perineurium of the optic nerve.

Dr. Hickson and Dr. Grenacher suppose the sheathing cells of the great rods, retinulæ of Grenacher, to be the nerve-terminals; and more recently Platten pretends that the optic nerve terminates in the crystalline cone. There is therefore no unanimity amongst previous writers, especially in matters of detail; as it is impossible that they can all be right, it is quite possible, as I assert, that they are all wrong.

Dr. Hickson's neurospongium, or terminal anastomosis, which is inadmissible on physiological grounds, is no nerve-plexus at all, but the tracheal plexus and the sustentacular framework of my retina.

It is exceedingly difficult to prepare sections which show the true retinal end-organs. This difficulty arises from the fact that the chloroform and alcohol used in the process of imbedding dissolve the fatty matters from the nerves, and the external extremities of my retinal rods are completely dissolved or disintegrated by the action of aqueous media.

I have, however, on many occasions succeeded in obtaining sections in which both the inner and outer extremities of the retinal rods, as well as the nerves, remain more or less unaltered. Another difficulty arises from the extreme transparency of these structures in very thin sections, and from the fact that they cannot be stained by any of the stains used in such researches; the outer ends of the rods are not affected by strong solutions of aniline dyes, except vesuvin *.

In thicker sections the numerous round cells between the retinal nerve-end organs, which are not connected with nerves, but with the sustentacular framework, entirely conceal the outer ends of the rods.

There are two methods which give good results; in both the tissues must be fixed either with osmic acid and absolute alcohol

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* The best demonstration of these organs is obtained by staining with a solution of vesuvin in aniline water. The solution must be quite freshly made, and unfortunately such preparations fade rapidly when mounted in balsam.

or in absolute alcohol, and imbedded in paraffin without the use of ether or turpentine. Very thin sections are then cut and fixed on the slide with shellac and kreosote. The cement must be thoroughly dried in the oven at the melting-point of the paraffin used, and on no account at a higher temperature.

The paraffin is next removed by turpentine. The slide is then wiped on its back and edges, and flooded with pure spirit, which is drained off, and immediately afterwards flooded with 75 per cent. alcohol and rapidly drained; Erhlich's logwood solution is then poured on the slide and washed off after a few minutes or longer by agitating the slide for a few moments in water, and it is again flooded with 75 per cent. alcohol. The washing is the most dangerous process, as if the specimens are kept too long in water the outer ends of the retinal rods will be entirely dissolved. Instead of Erhlich's logwood a solution of vesuvin in water may be used; it stains the retinal-end organs better than any of the aniline dyes. Saffranine in 50 per cent. alcohol, or a solution of fuchsine or eosine, may be used for staining, and the washings done with spirit, the results of which are often satisfactory. Spiller's purple gives excellent results, but the specimens are not permanent. The specimen, after flooding with 75 per cent. alcohol, is treated with pure alcohol, rapidly drained and cleared with clove-oil and mounted in balsam.

Or, after the first washing in water, the specimen may be mounted in glycerine, gradually adding stronger and stronger glycerine and water, and draining after each addition. I have found that with aniline dyes a very dilute solution of sodium carbonate, ·5 per cent., or aniline water is not inadmissible for washing out the excess of the stain.

Glycerine mounts, when successful, show the outer ends of the rods, either vacuolated or frequently partially dissolved, more plainly than balsam mounts.

The balsam mounts need very careful illumination, otherwise it is impossible to see the outer ends of the rods.

If we trace the optic nerve, we observe that its fibres run in larger or smaller bundles, invested in a very transparent sheath, or perineurium. They terminate in the palisade layer by entering the fusiform elements. The sheath is continued over the fusiform elements, and terminates on the inner surface of the basilar membrane. The tracheal vessels accompany the bundles of optic nerve-fibres, outside their sheath, and continue between the palisades, and ultimately pierce the basilar membrane and run between the great rods.

The figure given (Plate XXVII. fig. 1) is from the eye of a Hawk-moth, in which these details are larger and more easily seen than in the Blowfly. The palisade bodies do not reach the basilar membrane, but are prolonged as extremely transparent rods, 3 to 5 μ in diameter, in the fly and in most of the insects I have examined, and from 20 to 30 μ in length (Plate XXVII. figs. 2 and 3, *a*). These with the palisade cells, *b*, form my bacilli or retinal end-organs, the whole length of which is from 60 to 70 μ. The outer transparent portion is rarely straight, but usually strongly curved in a crook. They exhibit a fine longitudinal striation.

The outer ends of the rods evidently consist of some substance resembling mucin; they have the same refractive index and general characters as the mucin of the intestinal epithelial cells of the insect.

The inner extremity of the outer part of the rod is imbedded in the fasciculus of elongate cell-like palisade bodies, fig. 2, which form the inner portion of the retinal end-organs; each outer segment appears to be made up of a number of finer rods, 2 μ in diameter, pressed together into a cylinder; these produce the longitudinal striæ. Each small component rod lies on the inner surface of one of the fusiform cell-like bodies which form together the inner part of the retinal end-organ.

The outer ends of the rods are surrounded and, except in very thin sections, concealed by the small round chaplet-cells of Viallanes (fig. 2, *c*). These are connected with each other by fine processes and form a true adenoid sustentacular tissue, well seen in transverse sections of the pupa (fig. 4).

Comparison of the Bacillary Layer with the Bacillary Layer of the Vertebrate Retina.

In size and structure the elements of the retina are almost identical with those of the vertebrate; the optic nerve terminates in the protoplasmic inner segment, whilst the outer segment is transparent, resists stains, exhibits longitudinal striæ, and swells up with water in both. In both it is easily destroyed, and frequently exhibits vacuolation.

In most insects the outer, highly refractive ends of the retinal end-organs are imbedded in abundant pigment. The flies are the only exception, and in these the cells surrounding the bacilli are free from pigment.

The Tracheæ (Plate XXVII. fig. 3) form a dense network around the inner segments of the retinal end-organs in insects, and branches extend to and perforate the basilar membrane. These fine tracheæ are without any spiral markings, and are easily mistaken for fine nerve-twigs. The figure given (fig. 3) shows these tracheæ in a moth, and it can be readily seen that they lie between the nerve-end organs, and that they branch dichotomously between the great rods. The aniline stains at once colour the tracheæ, whilst they have no effect upon the nerves. These stains, however, attack the nerve-sheaths, but not the outer ends of the retinal end-organs. By the use of aniline stains, especially Spiller's purple, I have been able to trace the finer tracheal vessels, which have been constantly mistaken for nerves, to the larger tracheal trunks and in one of my photographs this relation is sufficiently evident.

The illustrations on Plate XXVII. show the large size of the bundles of optic nerve-fibres with their terminations in the retinal end-organs; they also show that nothing bearing any proportion to the magnitude of these nerve-cords passes through or even up to the basilar membrane. The basilar membrane is chitinous and has a cellular layer on both its inner and outer surface; that on its inner surface consists of branching or stellate cells, which are continuous with the sustentacular framework of my retina; the outer layer consists of pigment-cells, continuous with the pigment-sheaths of the great rods. The perforations in the chitinous layer of the basilar membrane are between and not opposite to the extremities of the great rods, and transmit the tracheal vessels.

The structure of the great rods has with some been the difficulty in accepting my views. The appearance of these structures in many sections is certainly perplexing. The reason is that which I have already insisted upon. In life they are hollow tubes filled and distended with fluid. In bad preparations they appear stellate in transverse sections and present no central cavity; in radial sections they are separated from each other by wide spaces, often filled by distended tracheal vessels.

In transverse sections, when unaltered by the process of imbedding, they are circular or hexagonal rings, with a large central cavity; they touch each other at their periphery, and the tracheal vessels appear as thick-walled but very small tubes. Each great rod is seen in such sections to be lined by a thin cuticular layer, which dips down between the sheathing cells; it is the folds of this membrane which appear as bright highly refracting points under unfavorable conditions of illumination. With direct central light, thin sections, with oil or water immersion-lenses, no longer present these appearances; there is no bundle of axial rods in such preparations when properly examined, only a thin cuticular lining.

Further evidence in favour of my views is, I believe, shortly forthcoming from the pen of an independent observer. Prof. Plateau informs me that last year, at Cologne, Dr. Exner showed the single image formed by the compound eye—the image in the plane of my basilar membrane formed by the uninjured eye, *i. e.* by my dioptron. I wait anxiously for the spring, as with fresh insects at command I have little doubt the demonstration of an erect picture in this region is perfectly easy.

The Development of the Compound Eye.

The development of the compound eye was described by Weismann in 1864 *. I have gone through a most laborious research, and in the main points my observations agree with those of the great German investigator. Weismann says it has long been known that the eye in insects is developed from two perfectly distinct parts—one from the nerve-centres of the larva, the other from the optic disc ("Augenscheibe," *l. c.* p. 194).

If we follow the development of the optic disc, we find it at first as a thin cellular expansion enveloping the anterior part of the hemisphere (or supra-œsophageal ganglion). It consists of cells (the optogenic cells of Viallanes) which are larger than those of the other discs; they measure 15 μ in diameter at an early period of the pupa state and have large clear nuclei. During the formation of the head, the eye-disc separates considerably from the hemisphere, the interspace being filled with the granular yelk-like substance of the somatic cavity of the pupa. The whole dioptron is developed by a division of the optogenic cells, as Claparède long ago showed. Each original cell corresponds to a single corneal facet. These cells form almost hemispherical projections on the outer surface of the disc and are soon covered by an extremely thin cuticular layer.

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* "Die Entwicklung der Dipteren," Leipzig, 1864. Reprinted from Köll. Zeitsch. f. w. Zool.

The cuticular layer is seen in my sections to dip slightly between the cells, whilst the corneal lens is secreted subsequently between the cell and the primitive cuticular layer. The lenses are, as I have already described them, perfectly distinct from the chitinous layer, giving rise to the condition I have designated the kistoid cornea. In adult pupæ the distinction is perfectly apparent, although Dr. Hickson has denied that my description is correct; the most patient reinvestigation entirely confirms my former statement.

So far my investigations entirely accord with Weismann's description. Weismann, however, believes that the great rods contain a nervous structure, which he describes, from optical sections, as resembling a bundle of fine, highly refractive, conducting threads ending at the crystalline cone. He has nothing to say of their manner of development, and only expresses the opinion that they appear more like definite threads than the angles of a solid rod.

These so-called axial threads, as I have stated above, are well seen in numerous transverse sections to be mere folds of a chitinous membrane enclosing a considerable empty cavity.

Weismann's description of the development of the nervous structures is as follows:—"The thin nerve-cord (*Stiel*) which unites the optic disc to the hemisphere still appears on the fifth day as a nervous cord; but on the twelfth day the pedicle can no longer be seen." He concludes, however, that it has spread out into an invisible layer over the whole surface of the ganglion. That he should have arrived at such a conclusion without sufficient evidence is quite unlike him. If, as he says and as is certainly the case, the nerve disappears entirely between the fifth and twelfth day, the opinion that the radial striæ (which, he says, appear later between the disc and the hemisphere) are the same nerve spread out, is not founded on fact.

We must remember that Weismann regarded the discs as expansions consisting of epiblast-cells. It was Ganin who, ten years later, first made sections and discovered their real structure. He found three distinct layers—Weismann's epiblastic layer; his own provisional layer, which covers it externally as a fine cellular expansion, which resembles the amnion of a mammalian embryo in being continuous with the periphery of the disc, in covering its whole outer surface, and in enclosing a cavity between it and the epiblast of the disc; and the mesoblastic layer, which fills the hollow cup-like cavity on the inner surface of the epiblastic layer, and which consists of a network of fine branching cells.

Weismann's own figure (52, plate xiii., *l. c.*) shows clearly that his supposed optic nerve is the mesoblast of the disc. My own observations show that the nervous pedicle of the optic disc becomes atrophied and disappears, whilst the nervous retina is developed as a papilla in front of the original optic pedicle.

In my former paper I described and gave figures of the manner in which a new retina is developed during the skin-shedding of the Cockroach; the original nervous pedicle of the disc corresponds to the nerve of the first few facets of the eye. As the number of facets is far greater after each ecdysis, so a new retina is developed from the nerve-centres as a distinct papilla; the first formed nerve and retina at the same time undergo atrophy.

I regard the original pedicle of the disc in the Blowfly (figs. 5, 6, & 7, *st.*) as a rudiment. It exhibits few, if any, nerve-fibres and consists chiefly of connective neuroglia continuous with the investing layer of the rudimentary hemisphere. The spongy mesoblastic tissue which Weismann mistook for an expansion of the nervous pedicle of the disc consists of the elements from which the tracheal vessels and pigmented fringes of the dioptron and neuron originate. This tissue extends into the dioptron, but only between the ingrowing optogenic cells, which become first columnar and then elongated rods, dividing during the process to form the cone and the investing cells of the great rods, and separating from each other to enclose the central cavity of the cone and the great rod. Claparède long ago correctly described the manner of the development of the cones and great rods.

Viallanes, like Weismann, but with less excuse, mistook the mesoblast of the disc for the optic nerve and believed that its fibres perforate the axes of the great rods. It is easy in thick sections to mistake fibres running between for fibres entering the optogenic cells.

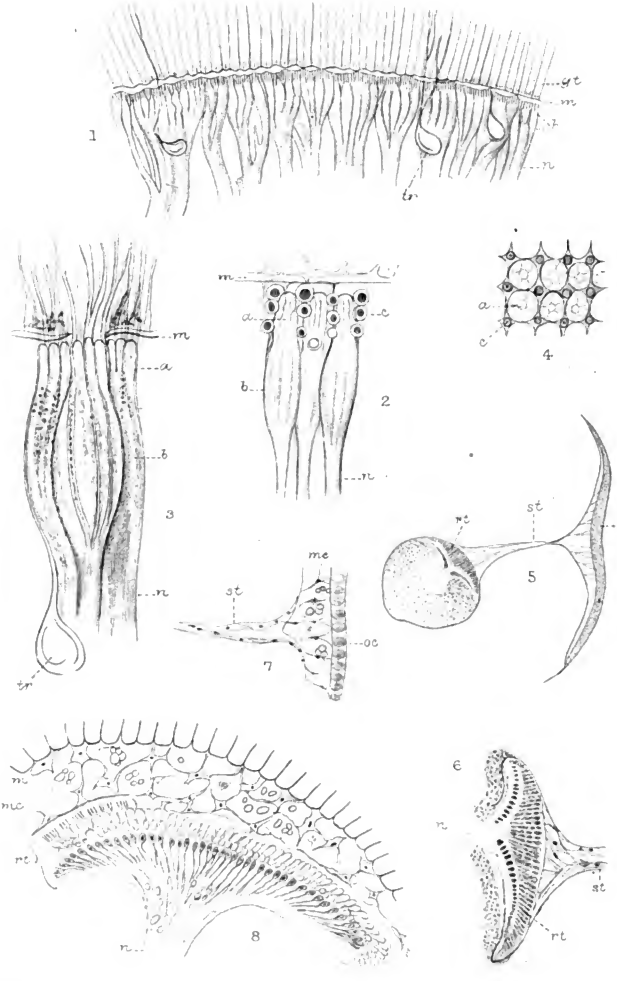
The nerve-papilla, from which the optic ganglia, the optic nerve, and the retina are developed, gradually grows outwards towards the dioptron (Plate XXVII. figs. 5–8, *n*). It is at first covered by a layer of columnar cells, which represent the epiblast of the nerve-centre; from this layer the bacillary layer of the retina is developed. These cells become converted into the retinal end-organs. The mesoblastic spongy tissue is gradually absorbed or converted into tracheal and connective elements, which ultimately form a thin layer between the retina and the basilar membrane of the dioptron.

The retina, even when the insect is nearly ready to escape from the pupa, is still separated from the dioptron by a space filled with branching cells (Plate XXVII. fig. 8, *mc*) and secondary yelk, so that the supposed entrance of nerve-fibres into the dioptron cannot be explained by any known process of development.

The continuity of the tracheæ of the dioptron and those of the mesoblast is the result of the penetration of the latter between the great rods during their inward growth; but during this period the nervous papilla is separated by a wide space filled with secondary yelk and reticular mesoblast from the ingrowing epithelial structures of the dioptron.

Thus, if my observations are correct, the retina, like that of a vertebrate, is entirely formed as an outgrowth from the central nervous system, while the dioptron, like the crystalline lens and the refractive structures generally, is formed from the external epiblast, which is more or less invaded by mesoblastic elements. With regard to the retina itself, it is undoubtedly, like the nerve-centres, no less epiblastic in the insect than in the vertebrate, as the hemispheres themselves, as well as the ventral ganglia, are formed from the embryonic epiblast.

In conclusion, I would add that it is scarcely fair to expect me to prove a negative, *i.e.* that no nerve-fibres pass to the dioptron. The onus rather lies with my opponents to prove that the great optic nerve does enter the dioptron, and to find its terminals. Even the most cursory glance at the works of Dr. Hickson, M. Berger, M. Viallanes, and others will show that they have given totally dissimilar representations; of these Dr. Hickson's are correct enough as representations of tracheal and mesoblastic skeletal tissues. I would ask, Which of the various structures



B.T.L. del. ad nat. Berjeau & Highley lith. West Newman imp.

RETINA OF BLOWFLY.

represented are to be considered as nerves? No one has yet figured one satisfactory representation of the optic-nerve fibres entering the great rods. Dr. Hickson says, "Morphology teaches us that the great rods are nerve-terminals." To appeal to morphology to settle the question appears to me to show on how slender a basis of observation the received view rests, and I should myself regard an appeal to morphology as one which is fatal to the received view; for, if morphology teaches us anything on this subject, it is that the retinal end-organs belong to that part of the epiblast from which the great nerve-centres are developed, and that the dioptric structures arise from the superficial or cutaneous epiblast.

DESCRIPTION OF PLATE XXVII.

Fig. 1. A section of the retina of a Hawk-moth; partly drawn from a photograph and finished from the section. *gt*, great rods; *m*, basilar membrane; *b*, bacillary layer; *n*, optic nerve; *tr*, tracheal vessel.

2. A section of the retina of a Blowfly. *c*, chaplet-cells of Viallanes. $\frac{1}{12}$-inch objective, water-immersion.

3. A portion of the retina of a Hawk-moth; drawn from a photograph, with details added from the specimen. The tracheal vessels seen passing through the basilar membrane are much more distinct in the photograph than in the specimen seen by the microscope; these are represented in the drawing as they appear in the photograph.

4. A transverse section through the bacillary layer of the retina of a Blowfly which had just emerged from the pupa.

5. A section of the optic disc and cephalic ganglion of a 3-day-old pupa. *o*, optic disc; *st*, stalk; *rt*, retina. 1-inch objective.

6. A portion of the same, showing the retina and inner extremity of the stalk.

7. A portion of the optic disc and stalk of the same. *oc*, optogenic cells; *mc*, mesoblastic cells. ¼-inch objective.

8. A section of the retina of a ten-day-old pupa. Showing the mesoblast elements between the retina and the basilar membrane. ¼-inch objective.

(The letters indicate the same parts in all the figures.)

On the Structure and Development of the Ovaries and their Appendages in the Blowfly (*Calliphora erythrocephala*). By B. Thompson Lowne, F.R.C.S., F.L.S., Hunterian Professor of Comparative Anatomy in the Royal College of Surgeons.

[Read 6th December, 1888.]

(Plate XXVIII.)

1. Introductory.
2. Development of the Ovaries and Ova.
3. The Oviducts and their appendages.
4. The structure of the Gum-glands.
5. Theoretical Considerations and Conclusions.
6. Bibliography.

1. *Introductory.*

The ovary of an insect is known to consist of a number of ovarian tubes connected with a single outlet, the oviduct.

The ova lie within a thin membranous tube, the *tunica propria*, and form an egg-string; this is enclosed within a follicle, the egg-follicle, the so-called peritoneal coat. In each egg-string three parts are usually recognized—the terminal thread, the terminal chamber, and the egg-chamber or chambers.

In the Blowfly each ovary consists of about a hundred ovarian follicles, springing from the dilated anterior end, or calyx, of the ovarian duct. When the ovary is mature (Pl. XXVIII. fig. 8) the terminal threads exist as mere rudiments (*t.f.*), and, properly speaking, there are no terminal chambers. In the young ovary, however (fig. 6), the terminal chambers are well marked (*t.c.*).

Much discussion is found in the writings of various authors as to the nature and import of the terminal thread.

Brandt (6*) maintains that there is no fundamental difference between ovaries with and ovaries without terminal threads (*l. c.* p. 21)—"these are mere prolongations of the ovarian tubes or of their peritoneal investment. In the former case they have the same morphological significance as the rest of the ovarian tube, in the latter they are mere connective or suspensory bands." My own observations have led me to exactly the same conclusion.

The Terminal Chamber (fig. 6, *t.c.*) is filled with small cells. Stein (24) was apparently the first to distinguish the terminal chamber as an important constituent of the ovary; he calls it the germinal chamber (*Keimfach*). He was followed by Prof. Huxley (10, 11), Sir John Lubbock (19), Claus (8), and others. Stein enunciated the view that the function of the terminal chamber is the formation of germ-yelks; but he does not regard all the cells in the chamber as germ-yelks. Sir John Lubbock went a step further and wrote as follows:—"In their earliest stage, the egg-cell and the vitelligenous cells cannot be distinguished from each other, and no one, I think, who has carefully examined the upper part of the egg-tube in any Hemipterous or Dipterous insect can fail to be of the same opinion."

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* The numbers in parentheses following authors' names refer to corresponding numbers in the Bibliography given at the end of this paper.

I agree entirely with Sir John Lubbock in this, that all the cells in the terminal chamber are alike; but when he concludes, "The egg-tube contains, indeed, at this end, cells which are neither vitelligenous nor egg-cells, but which are capable of becoming, under certain circumstances, either one or the other," I cannot agree with him, and my reasons will appear in the sequel.

The Egg-chambers.—This term was first applied, I believe, by Brandt (6) to that portion of the egg-tube which contains definite ova. In some insects each egg is formed from a single cell; this is so in the Orthoptera; such ova are designated by Brandt *panoïstic.* In other insects several cells are concerned in the formation of the ovum; these ova he termed *meroïstic.*

In the meroïstic egg Brandt calls the lowest cell the egg-cell, the others he terms nutrient or yelk-cells.

The part played by these nutrient cells is a matter upon which there is great divergence of opinion. Brandt's view, which has been generally adopted in text-books and widely accepted, is this:—The egg-cell in the meroïstic egg is the only cell enclosed by the chorion, and the nutrient cells remain outside and ultimately disappear. These are supposed to be in some way concerned in the nutrition of the egg-cell. The great increase in the size of the egg-cell is due to the deposition of yelk-granules within it, around its nucleus, which Brandt regards as the germinal vesicle. Similar changes also occur in the panoïstic egg, which only differs from the meroïstic in the absence of the nutrient cells.

Weismann (26) maintains, on the other hand, that all the cells, the nutrient as well as the egg-cell, are enclosed in the chorion, and that they all take part in the formation of the yelk, ultimately fusing into a single mass; and this, as I shall show hereafter, agrees with my own observations.

With regard to the import of Brandt's egg-cell there is less divergence of opinion; the identification of its nucleus with the germinal vesicle has been regarded as of the highest importance, and numerous attempts have been made to show that the nucleus of the egg-cell differs from those of the nutrient cells, from the very earliest stages of the egg-formation. Thus Dr. Claus (8) (p. 44) writes:—"The questions, the answers to which are of the highest importance, are: from whence is the germinal vesicle derived? and what is its relation to the great yelk-cells? The identification of the germinal vesicle appears to be difficult, and the earlier observers came to no certain result." After quoting from Sir John Lubbock's paper (19) he continues, "I believe my own observations enable me to prove that the epithelial cells, the yelk-forming cells, and the egg-cell are modifications of originally identical elements." Yet Claus thinks he distinguishes the germinal vesicle in very immature ova by "its smaller size and clearer contents" from the nuclei of the adjacent yelk-cells. Meyer's (20) statements are in direct opposition to this; according to these there are several germinal vesicles, each nucleus becomes invested by a membrane, each making, as it were, an attempt at forming an egg, the lowest nucleus persisting and the others disappearing.

In my opinion by far the best and most accurate description of the development of the ovarian eggs in the Fly is due to Weismann (26); it is as follows:—"The ovaries are developed very slowly in the Muscidæ; when the fly emerges from the pupa none of the eggs are formed, although the ovary may be recognized in the embryo" (*l. c.* p. 206). Weismann then refers to a description of the ovary in the adult larva of the closely-allied *Sarcophaga carnaria* (at page 134), "Concerning the female sexual organs in the larva of *Musca vomitoria* I have no observations; I must therefore fall back on those on the closely-allied *S. carnaria*. In a larva one centimetre long, the ovary has a diameter of 0·29^{m}, is flask-shaped, and differs in its histological structure from the male sexual gland; here we find no mother-cells, the structureless sheath encloses only small round cells ·013^{m} in diameter with nuclei ·01^{m}, exceedingly clear and exhibiting nucleoli. These cells are isolated with difficulty, as they adhere closely to each other. If we tear the ovarium of an adult larva no further structure is visible; but if a gentle pressure be applied to the uninjured ovary one may distinguish the first rudiments of the ovarian tubes. In the upper half of the ovary they appear as cylindrical follicles lying parallel to each other. They are all united above without any point (terminal thread ?) being visible, below they are lost in the cellular mass. The diameter of a follicle averages ·04 ^{m}. The ovarian follicles consist of a sheath of fine structureless membrane and its contents, which differs in no way from the surrounding cell-mass. The sheaths are a cuticular excretion from the outer surface of the cells forming the cylinders." (He continues on page 206) "So that, as I have shown above, the original soft mass of cells with which the ovarian capsule is filled becomes differentiated, in part, into solid strings, which shed a cuticle from their surface, and the ovary comes to consist of a small-celled ground-substance which fills the capsule, in which solid cellular strings are imbedded, each enclosed in a fine structureless membrane; of an outer and inner epithelium, a tender albuminous contents in which free nuclei are imbedded, as Meyer describes in the youngest condition of the ovary, there is as yet no trace. The term egg-tubes is hardly admissible at this stage, it is only later by the differentiation into a wall and contents that they become tubes."

"On the seventh day of the pupa stage the egg-tubes still only occupy a small zone of the flask-shaped ovarium (Taf. xiv. fig. 70); they lie close together parallel to the long axis of the ovary and still exhibit their original simple structure, only the contained cells are somewhat larger and therefore more distinctly seen. These cells are spherical, and their nuclei are easily distinguished. The cuticular sheaths end above in rounded domes."

"By the fourteenth day the investing sheaths of the egg-tubes are considerably more developed, and their outer form is altered; the blind end is now drawn out into a point, the middle part is swollen and the posterior part contracted. Still the lumen is filled with cells disposed without definite order; no regular epithelium is yet visible, but there is a great difference in the size of the cells, the central ones being larger than those of the periphery. A little later these changes are more conspicuous, and the egg-tube exhibits a stem, a chamber, and a nipple-like appendage" [Stein's end-chamber], "the narrowed blind end of the tube. In the chamber there is a distinct separation of the cells, small cells line the follicle in a single layer, as an epithelium enclosing the larger cells; from the latter the egg is ultimately formed."

"The development of the ovary shows that the life of the fly must last several weeks. A ripe egg is first found in the lowest part of the ovarian follicle after the insect has flown about for a long time; then a second, third, or even a fourth chamber has been developed in which there are eggs in different stages of formation."

"The development of these eggs takes place as follows. The large cells which lie within the epithelium of the egg-chamber enlarge, by their rapid growth they lose their original spherical form and appear flattened against each other as more or less hexagonal sections of a sphere."

"These cells each enclose a very distinct transparent vesicular nucleus, and consist of homogeneous, but highly refractive cell-substance. With increase of the cells by growth this cell-substance becomes finely granular and afterwards dark and yelk-like. The cell-membranes then disappear, and the yelk formed in the cells fuses into a mass; so also all the nuclei disappear except one, which becomes the germinal vesicle. It appears that the nucleus of the cell which lies lowest in the chamber always furnishes the germinal vesicle. This seems to have orginated Meyer's statements."

Weismann concludes with the words *, "So far as the Diptera are concerned, my view accords with Lubbock's; we agree that the egg of the Diptera is not derived from a single cell, but is a compound formation, like the egg of Cestodes or Trematodes, in which a germogen and vitelligen combine their products, for the composition of an egg."

Stuhlmann (25) holds the same views as Brandt with regard to the fate of the nutrient cells, and renews the old controversy with regard to the germinal vesicle. The principal results at which he arrives concerning it are summed up by him in the following words:—"I have been enabled by a series of observations on insects' eggs to establish the extrusion of large balls from the germinal vesicle which are afterwards lost in the egg-plasm. Later the germinal vesicle disappears until at last at the upper egg-pole we again find it as the segmentation nucleus" †.

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* Dass das Ei der Dipteren nicht von einer einzigen Zelle abstammt, sondern ein ebenso zusammengesetztes Gebilde ist als die Eier der Cestoden und Trematoden, bei denen Dotterstock und Keimstock ihre Producte zur Bildung des Eies zusammenfliessen lassen" (*l. c.* p. 209).

† "Es ist mir nun gelungen, an einer Reihe von Insekteneiern sicher einen Austritt von grossen Ballen aus dem Keimbläschen zu constatiren, die sich

Such an outstreaming of nuclear particles (*Ballen*) is undoubtedly seen in the lowest nucleus of the egg, but it also occurs in the nuclei of the so-called nutrient cells, and in all the nuclei of the various organs of the larva during their degeneration in the first stages of the pupa. It is one of the most characteristic phenomena of yelk-formation, whether in the egg or the pupa, whilst it is quite unlike anything which has been observed in relation to the well-known germinal vesicles of other animals.

Lastly, Henking (9) has quite recently figured and described the ripe ovarian egg of the Blowfly with the nutrient cells outside the chorion, and his figure has fortunately enabled me to discover the error into which Brandt and his followers have fallen. The appearance represented by Henking is an exceptional phenomenon which I have frequently observed. When the eggs approach maturity they enlarge so rapidly that the anterior pole of an egg is often pushed into a chamber above it containing a half-developed ovum, which then assumes the form of a cap over the anterior pole of the ripe egg. I have sections which exhibit this phenomenon in several stages. Whenever the young ovum in the chamber above the ripe egg is present in an un-deformed condition the cap on the ripe egg is absent, and whenever a cap is present there is no second chamber in the egg-follicle. So many of the egg-tubes exhibit transitional conditions in which the ripe egg impinges upon or slightly indents the half-formed egg in the chamber above it that, with good sections, I cannot believe anyone would have the slightest doubt as to the nature of the phenomenon.

2. *The Development of the Ovaries and Ova.*

The earliest stage of development in which I have as yet seen the ovaries of the Fly is in the four-day old pupa (Pl. XXVIII. fig. 4). In this stage they are apparently slightly in advance of the stage described by Weismann as that of the seven-day-old pupa. The discrepancy is probably due to the fact that I worked in summer, and Weismann's observations were made in winter. The earlier stages of the pupa are well known to be greatly influenced by the external temperature.

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nachher im Eiplasma auflösen. Später verschwindet das Keimbläschen von unseren Blicken, bis wir endlich am oberen Eipol den Furchungskern wiederfinden" (*l. c.* p. 12).

At this stage the ovary is pear-shaped ·25 m. in diameter and ·34 to ·4 m. in length. It is enclosed in a thin but perfectly distinct cellular capsule (*c*). It consists of a stroma of small cells less than 5 μ in diameter, enclosing the bundle of egg-strings (*e.s*). These are closely packed together and occupy the anterior rounded half of the ovary.

The posterior narrow part of the ovary (*cl*) is filled with small round cells precisely like those which form the egg-strings, except that the latter are slightly larger, 5 μ.

The egg-strings present, even at this period, a narrower constricted posterior and a more dilated anterior portion; they are like long narrow flasks, the neck measures 5 μ and the dilated portion 15 μ in diameter. The whole consists of small closely packed cells enclosed in a fine cuticular membrane. The necks of the egg-strings appear to be open behind, where the cells of the posterior part of the ovary, destined to form the duct, are continuous with those within the flask-like egg-strings. There is as yet no trace of a lumen in the solid rudiment of the oviduct.

The cells between and around the egg-tubes are, however, already distinctly elongated and form a stroma, in which the egg-strings lie, so differing entirely from the cells which form the egg-strings and fill the calyx of the ovary.

The next stage of development is seen in the half-formed pupa, about the tenth day (Plate XXVIII. fig. 5); at this stage the ovary is apparently cup-shaped, it appears crescentic in lateral sections, with the concavity of the crescent in front; it has a diameter of ·5 m., but is still about ·3 m. in thickness, measured from before backwards in its thickest part. That part of the ovary not occupied by the egg-strings is excavated by numerous channels; these form the calyx of the oviduct and cover the whole convex surface of the organ. The egg-strings are now so broad in front that I shall term them egg-follicles. The egg-follicles (*os.*) are ovoid masses of small cells, each with a very narrow stalk (*st.*) The stalk is apparently filled by a single row of cells, and its investing cuticle is frequently transversely wrinkled, which often produces an appearance of striation. Possibly this may have given rise to the very remarkable view held by Schneider (23) that the egg-tubes are developed within the alar muscles of the dorsal vessel.

Each rudimentary egg-follicle is now surrounded by a pouch, the ovarian follicle (*of.*), formed of fusiform mesoblastic elements. This is the so-called peritoneal coat of Stein. The ovarian follicles at this stage do not appear to open directly into the channels in the calyx of the ovary, but to be closed by a cellular mass (x), with which the stalks of the egg-follicles are continuous. This cellular mass appears to me to be formed by the cells which filled the posterior part of the ovarian capsule at the earlier stage of development above described.

Between the ovarian follicles, which no longer lie close together, the elements of the pseudo-yelk of the pupa (*psy*) are found in abundance. These consist of globules (*Kornchenkugeln*) and leucocytes; they are derived from the breaking up of the fat-bodies and the tissues of the larva. The pseudo-yelk, at this period, forms the greater part of the bulk of the pupa. Indeed, if such a pupa be opened it appears to contain nothing but a milky fluid, in which all the tender half-developed imaginal tissues are concealed.

There is as yet no differentiation of the contents of the egg-follicles into epithelium, yelk, or germ-cells.

Even at the time when the fly is ready to escape from the pupa the ovary remains in a condition which differs but little from the stage last described, except in the form of the egg-follicles, which now exhibit a narrow stalk and an ovoid middle portion constricted above so as to form a small, but distinct nipple-like terminal chamber (fig. 7, *t.c.*).

The peritoneal coat (*of*), or ovarian follicle, is also more developed, is much thicker, and exhibits numerous tracheal vessels (*tr.*). There is still, however, no trace of differentiation in the cells contained within the egg-chamber, and these only differ from those in the terminal chamber in being slightly larger.

In the observation of the further developmental changes we must have recourse to flies which have been on the wing for some time, and therefore the age of these insects is unknown. Development progresses very slowly in captive insects, and as these never unite with the males, there is no certainty that development progresses at the same rate or in the same manner as in free insects.

The next stage which I shall describe is represented in Pl. XXVIII. fig. 6. The ovary now measures ·35 m. in thickness and is discoid. The calyx is very thin, as the ducts which form it appear to be flattened by the lateral growth of the organ.

The whole ovary has also altered its position; the surface from which the oviduct originates is now turned towards the ventral aspect of the insect, so that the long axes of the egg-follicles are transverse to the axis of the body. I shall still, however, call the end of the egg-follicle which is nearest to the oviduct, posterior, to facilitate comparison and avoid confusion.

The ovarian follicles are now more fully developed, and loosely invest the posterior part of the egg-strings. The anterior part, the terminal chamber, is closely covered by the anterior part of the follicle, which is so thin that it can scarcely be traced as a distinct layer. The posterior part of the egg-follicle exhibits a distinct epithelial layer, which is continuous with the epithelium of the calicine duct, and the follicles open freely into these ducts.

The three parts of the egg-string are very distinct, within a very fine cuticular tunica propria. The stalk is filled by a single layer of epithelium; there is no lumen and no double epithelial layer; but where the stalk enlarges near the egg-chamber there is more than a single layer of cells, but these are irregularly arranged.

The egg-chamber, when fully formed, contains a group of yelk-cells flattened by mutual pressure and surrounded by an epithelial capsule (*ec*), which is continuous with the cells of the stalk.

In some of the tubes a second egg-chamber is seen in process of formation (Pl. XXVIII. fig. 7), with a cup-like epithelial investment. In others the first egg-chamber is in the same condition; the cells destined to form the egg are still round and scarcely differentiated from those of the terminal chamber. It appears to me that the epithelial investment of the ovum grows up from the stalk, and that all the cells of the terminal chamber develop into yelk-cells.

The gradual transition from the small round cells of the terminal chamber to yelk-cells is very marked, so also is the upper edge of the epithelial cup (fig. 7, *y*), which ends abruptly in a thin edge, whilst the continuity of the epithelium of the stalk and of the egg is equally distinct.

The large yelk-cells stain very deeply with alkaline carmine, and the colour is not washed out by 5 per cent. solution of acetic acid. They average 12 μ in diameter, and all the cells in an egg are precisely similar, and have nuclei which are rich in chromatin granules. There is no cell with a clear nucleus, and nothing which I can recognize as a germinal vesicle.

In mature insects ready to lay eggs the ovaries occupy the greater part of the cavity of the abdomen. There are about one hundred egg-tubes (80 to 100) in each ovary, each having four, five, or even six egg-chambers in different stages of development (fig. 8).

A mature egg occupies the most posterior chamber (fig. 8, *a*), a partially formed egg is seen in the second chamber, whilst the third, fourth, and terminal chambers contain very rudimentary ova. The whole terminates in a small empty, hollow, end-thread (*tf*).

The cuticular tunica propria closely surrounds the egg and egg-strings, whilst the thin greatly distended egg-follicle passes from one egg to the other, leaving a considerable space between the eggs; it does not follow the outline of the egg-string between successive ova. The egg-string between the second and third chambers (tp^1) is exactly similar to the egg-stalk of the first chamber in the early stages of its development.

The two or three anterior chambers are filled with small round cells like those of the terminal chamber or the whole egg-follicle at an earlier period. The unripe egg in the second chamber (ec^2) consists of large yelk-cells enclosed in an epithelial chorion. The lowest cell in such eggs is, however, always much larger, usually twice as large as the others, but its nucleus is also nearly twice as large, and stains just as deeply. It also contains the same kind of granules as the others. In these statements I agree in no way with Brandt and Stuhlmann. Brandt states that the nucleus of the lowest cell is large and clear, Stuhlmann that it is very much smaller than the other nuclei, and that it is clear and flattened against the chorion. According to my observations it is neither one nor the other, and only differs from the nuclei of the other cells in being larger.

The yelk-cells ultimately attain a giant size; the largest cell, when full-grown, measures 200 μ in its longest diameter, and has a nucleus of 80 μ in diameter. When the egg is enlarged to about two thirds of its maximum size the granules in the largest nucleus appear to stream out, the nucleus itself shrivels and is ultmately lost, whilst the whole protoplasm of the cell assumes a granular yelk-like appearance, in which the nuclear granules can no longer be distinguished. The remaining cells undergo the some changes, and soon become fused with each other and with the yelk formed from the lowest cell.

The nuclei during these changes present a very variable appearance; but all the changes of the nucleus are similar to those which characterize the nuclei of the degenerating cells of the larva, during the formation of the pseudo-yelk of the pupa—a phenomenon well seen in the nuclei of the cells of the salivary glands and fat-bodies of the larva during their histolysis.

I conclude therefore that the several cells from which the yelk of the Dipterous egg is formed are of equal morphological significance, that these all undergo histolytic changes, and so form the yelk of the mature ovarian ovum.

So far as my observations go, there is no reason for supposing one nucleus rather than another is the germinal vesicle.

When I first began this investigation, more than two years ago, I looked for days in vain for some character by which I might recognize the germinal vesicle. Sometimes one nucleus, sometimes another presents a clearer contents and smaller diameter, and frequently several nuclei appear to possess equal claims in this respect to be considered the nucleus of the germ-cell.

As the young ova approach the condition of maturity, the cell-substance becomes more and more distinctly granular, the nuclei lose their sharp contour, and exhibit what Stuhlmann describes as an extrusion or outstreaming of nuclear particles, whilst these are lost to view in the granular surrounding protoplasm, and the cells themselves become fused into a single yelk-mass. These changes commence in the lowest and largest cell of the egg; but precisely the same changes afterwards occur in the remaining cells as each attains its full growth.

The mature ova consist of a yelk surrounded by two membranes, the vitelline membrane and the chorion. Such ova are closely embraced by the structureless cuticular membrana propria, and lie loosely in the distended ovarian follicle, which is now a very thin-walled tube surrounded by a dense network of tracheal vessels.

The yelk consists of an outer clearer layer (Pl. XXVIII. fig. 11, *a*) and an inner granular substance (fig. 11, *b*), but neither contain any nuclei or cellular elements of any kind.

The clear peripheral layer of the yelk exists in the unimpregnated eggs whilst they still lie in the ovary; this layer was described by Weismann, and called by him the *Blastoderm plasma* (*Keimhautblastem*). He supposed that it is this layer which forms the blastoderm. In my sections it projects in places as if it possessed the power of amœboid movement, more especially at the anterior egg-pole * (fig. 10, *a*); these may, however, be the result of post-mortem contraction. The central granular yelk-substance consists of small granules, 2 to 3 μ in diameter (fig. 11), imbedded in an apparently structureless, possibly in the living egg semifluid, matrix. These granules are spheroidal, stain deeply, and exhibit either a dark or light centre with alterations of the focus of the microscope. In the ripe unimpregnated ovum I have entirely failed to find any nuclei or cellular elements of any kind, and I feel sure that if any such elements were present they would be readily distinguished in my sections.

It is not necessary for my purpose to enter into any details in regard to the structure of the chorion and the nature of the vitelline membrane; there are, however, some controverted points upon which I would say a few words.

It is generally held that the epithelium of the egg forms the chorion as an exudation from its inner surface (E. Korschelt, 14; Weismann, 26). Whether this is so or whether the chorion is formed from the cells themselves (Leuckart, 16), the manner in which the ova leave the oviducts is entirely in favour of the latter view. This is effected by the rupture of the remaining rudiment of the egg-string between the ripe egg and the imperfect ovum immediately in front of it. Thus the thin tunica propria and the epithelium of the egg descend in the ovarian follicle and enter the oviduct together. The remains of the egg-string attached to the unripe ovum in the ovarian follicle have been seen and described by several observers, notably by Müller, Landois (15), and Leuckart (16). I hold therefore that whether the cellular epithelium is shed with the thin cuticular egg-sheath in the oviduct, or whether it remains as the chorion itself, it belongs entirely to the ovum, and cannot be regarded as the epithelium of the ovarian follicle, which is quite distinct and remains in the follicle.

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* The polar globules of Robin, which he described as formed by budding and fission, are possibly only mobile processes of this layer in a contracting yelk.

I am also inclined to regard the vitelline membrane as the cuticular exudation from the inner surface of the epithelium of the ovum and the chorion as the modified epithelium itself. The cuticular sheath which leaves the ovarian follicle with the egg is, I have little doubt, the epichorionic membrane described by Leuckart, Robin, and Kölliker. The shedding of the outermost covering of the egg, probably the epichorionic membrane, and possibly also of the epithelial chorion, was observed by Brandt in the Field-crickets in transit through the oviduct, forming what he designates corpora lutea.

The micropyle-canal, which, in the Diptera, extends the whole length of the dorsal surface of the egg, is an infolding of the chorion (Pl. XXVIII. fig. 9). It is extended over the anterior egg-pole (fig. 10), forming a considerable chamber in the floor of which the micropyle is situated (fig. 10, *m*).

The micropyle (figs. 12 & 13) is a small, almost quadrilateral opening (fig. 12), 2·5 μ in diameter; it is surrounded by a number of radiating folds which project on the outer surface of the chorion, and by a circular area composed of small hexagonal cells. These correspond in size to the hexagonal fields with which the rest of the chorion is sculptured.

The open micropyle-canal is brought into relation first with the orifices of the gum-glands, and later with those of the spermatophorous capsules during the descent of the egg through the genital canal. Henking (9) found spermatic filaments in the micropyle-canal.

3. *The Oviducts and their Appendages.*

The general form and arrangement of these parts is well known, so that the following description will suffice to indicate their arrangement for my present purpose.

The ovarian ducts are two in number (fig. 2), and these form a common oviduct (*od*) by their union. The common oviduct opens into the pouch-like anterior extremity of the vagina on its dorsal aspect.

Stein describes it as opening on the ventral surface in Beetles. I formerly fell into the same error; and it is exceedingly difficult in dissections to determine this point. Sections of the entire insect show at once the true relations of the parts.

The pouch-like anterior part of the vagina is very distinct from the posterior part; that portion of it in front of the orifice of the common oviduct (fig. 3, *b*) in the young insect is the ***bursa copulatrix*** of authors. The ***bursa*** in the egg-laying insect is no longer distinct, but forms the anterior part of the vaginal pouch.

I shall call the vaginal pouch the uterus, a term applied to it by Palmén (21) to distinguish it from the posterior tubular part of the vagina. If the term is not morphologically, it is at least physiologically correct, as an egg is frequently retained in it until the embryo is ready to escape from the shell.

There is at present some uncertainty as to the exact manner in which the common oviduct is developed; although it is quite certain that the ovarian ducts are developed from the posterior portion of the ovary, as Palmén has distinctly shown (21). The same observer also shows that the vagina, uterus, and their appendages are formed by an invagination of the external integument, or rather of the hypoderm. My own observations entirely confirm Palmén's statements. Although I have not been able to trace the development of the common oviduct, its structure and the manner in which the common duct of the testicles is formed in the Fly (Weismann, *l. c.* Taf. xiv. fig. 68) indicate that it is formed from the prolonged posterior parts of the ovaries.

So far I have stated nothing concerning the anatomy of these parts which has not been frequently observed and generally admitted. I must now, however, enter into some details which are not, so far as I know, to be found elsewhere.

The common oviduct in the Blowfly terminates in two distinct enlargements (figs. 1 and 3). The more anterior is due to a thickening of its muscular coat where a thick retractor muscle (*m*) is inserted into it. This withdraws the parts with the ovipositor. The second or terminal enlargement (*os*) is, however, a pouch or bulb lined by a greatly plicated intima, and capable of distention, so that it encloses the entire egg during its passage through the oviduct. One egg is frequently found in this section of the oviduct whilst another occupies the uterine cavity.

The great interest of this pouch is that the gum-glands (*gl*) or colleterial glands, as they are sometimes called, open by two slender ducts (*d*) into it, and not, as is usually believed, into the uterus itself.

Although I have frequently satisfied myself of this, both by section and by careful dissection, this point is of such importance, that I shall enter into an examination of the views of previous writers with regard to the termination of these ducts.

It is quite possible that several distinct glands have been confounded under the term gum-glands; indeed it is generally used for any accessory gland connected with the sexual canal. These glands are generally described as opening into the vagina or uterus. Stein (24) gives a great number of figures representing the oviducts, uterus, and appendages in the Coleoptera; in many it is difficult to identify the gum-glands. In *Hydrophilus* (*l. c.* Taf. iv. fig. iii) he represents the gum-glands as opening into the upper part of the ovarian duct. They are branching tubules which evidently form part of the ovary itself; and, judging by his excellent figure, are identical with the so-called gum-glands in the Blowfly.

Except in the Hydrophylidæ, Stein considers the gum-glands as a portion of what he terms the "apparatus of fertilization" (*Befruchtungs-Organe*), and represents them as if they opened into the spermatophorous capsules or their duct; although in many cases it is almost evident from his figures that they open into the oviduct. In some of his figures the spermatophorous capsules are represented opening into the oviduct (Taf. i. fig. vi), whilst in others they are correctly represented opening into the uterus, whilst the gum-glands open into the oviduct (Taf. ii. figs. i, ii, and iii).

Tracing the gum-gland in the Blowfly from its ovarian extremity, it lies first under and close to the ovarian duct; it then leaves this duct and comes into relation with the spermatophorous capsule, around which it forms a loop. The duct of the gum-gland commences at the termination of this loop, and is easily overlooked, as it is in close contact with the duct of the spermatophorous capsule, round which it turns and runs forward in close contact with the dorsal wall of the uterus and oviduct to terminate in the bulb of the oviduct. It is not difficult to understand how this duct has been overlooked, or how it has been supposed that the glands open into or with the seminiferous capsules. The gum-glands have also probably been confounded with true vaginal glands, which appear to exist in some insects.

I shall again refer to the gum-glands in a special section of the present paper in relation to their structure and functions.

The uterus (figs. 1, 2, 3, *ut.*) is a thick-walled sac lined by a strong cuticular membrane, very different to the thin cuticular membrane lining the oviduct. It has a diverticulum or pouch (*p*) on its dorsal wall immediately behind the orifice of the common oviduct. This pouch (*sacculus*, figs. 1, 2, and 3, *p*) is lined by a very thick laminated cuticle with a projecting median ridge which appears to divide it into two lateral pockets. Each of these pockets opens behind into the uterus, and is usually filled with a clear colloid mass, which stains very deeply with alkaline carmine. It has all the appearance of being the same material as that which cements the eggs together when they have been deposited. The same contraction of the uterus which expels the egg would certainly expel some of this material from the uterine pouch.

4. *The Structure of the Gum-glands.*

Although I have used the term gum-glands to designate these organs, it will be seen that there is nothing in their structure to justify its use. And although they are usually regarded as secreting-glands which form a glue or cement for the attachment of the eggs, a function first apparently ascribed to them by Burmeister (7) and afterwards by Loew (18), Stein, who has examined these structures with more care perhaps than any other writer, entirely discards the view. He regards the so-called gum-glands as accessory organs of fertilization except in the Hydrophilidæ, where they open into the calyx of the ovary; and, curiously enough, disregarding the extreme improbability that gum-glands would open in such a situation, makes an exception in these insects, and regards the glands as gum-glands. Stein further identifies these glands in the Diptera with his "glandular portion of the organs of fertilization."

With regard to the histology of these glands, very little, if anything, can be said to have been recorded of a satisfactory character. Stein gives several very remarkable figures (*l. c.* pl. ix. figs. i, v, and xii) of their histological structure, with the following description:—

"The fine structure of the glands is nearly the same in all Beetles; they belong to that class of glands which yield a fluid secretion, and which are tubular, follicular, or exhibit bladder-like cavities. In the gland-follicles the proper elements of the gland form a manifold layer of nucleated cells which prepare the secretion. Between these cells very fine wavy canals spread into the follicles, formed as outgrowths of the epithelial coat (of the central cavity), and terminate either in blind ends or within the cells*.

"In general the contour of the gland-follicles is the same as that of the epithelial coat of the central cavity . . . . . . *The secreting-cells lie between the epithelial and peritoneal coats* [the italics are mine] without order, near and over each other, and not united together. In form they are round, oval, or egg-shaped; in the latter case the blunt end is turned outwards, and the outlines of the cells, when one examines the entire follicle under a certain pressure, are not generally distinctly seen, so many lie over each other, and the cells, owing to their granular contents, are so opaque" (pp. 102, 103).

Leuckart (16*a*), in his memoir on the Pupiparæ, gives a figure of the corresponding gland of *Melophagus ovinus*, which, although on a much smaller scale, represents a similar appearance, and gives a description which corresponds nearly with Stein's.

These figures and descriptions are very difficult to understand, except on the supposition that both Stein and Leuckart examined glands with a quantity of adherent fat-cells. The fat-cells of the ovary form a large mass on its posterior aspect, and closely surround and adhere to the gum-glands. These fat-cells, when half empty, as they always are in the egg-laying female, exhibit appearances, in optical section, which could be interpreted without difficulty, as Stein and Leuckart have interpreted them; possibly the fine tubes are the fine tracheæ of the fat-glands, whilst the cells figured by Stein are undoubtedly those of the fat-body, of which I give a figure (Pl. XXVIII. fig. 15) for comparison. Sir John Lubbock (19), describing the corresponding glands in *Coccus Persicæ*, gives a totally different description. He says:—

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* "Zwischen diesen Zellen verbreiten sich am Follikel sehr feine geschlängelte Kanäle welche von Austulpungen der Epithelealhaut gebildet werden, und die nach aussen entweder blind endigen, oder an einer Zelle endigen."

"They are six in number, four large and two small, the latter being apparently attached by a short stalk to the peduncle of the large one which is furthest from the vulva. They lie three on each side, and their ducts open into the egg-canal close together and about halfway between the vulva and the division of the egg-canal into two oviducts. The internal structure is very distinct and interesting. It consists of many cells lying loose in the internal cavity, and resembling very much in form, size, and appearance the vitelligenous cells of the egg-follicle."

I have been unable to find any other published details on the structure of these glands, which I shall now give from my own observations.

The gum-glands in the Blowfly are simple tubes, tortuous rather than convoluted, 2 m. in length, with an average diameter of ·175 m. They have a glistening white appearance, and are beaded over the surface from the projection of the cells lining them. In sections these glands are seen to consist of an outer musculo-cellular coat, like the so-called peritoneal coat of the oviduct. This is lined by a single layer of large epithelial cells. The lumen is filled by a granular fluid or semifluid substance. This is coagulated by alcohol, the granules suspended in it are blackened by osmic acid, and the intergranular material is scarcely stained by alkaline solutions of carmine. In this respect it differs entirely from the substance contained in the uterine pockets and from that with which the eggs are cemented together.

The epithelial cells which surround the lumen of the gland are irregular in form and measure, on an average, 80 μ in diameter, and from 30 to 40 μ in thickness. Many of these cells contain very remarkable spherical corpuscles, usually one in each cell (figs. 15 to 20). Besides these, some of the cells exhibit an oblong nucleus surrounded by a clear area (Pl. XXVIII. fig. 16).

In females in which the ovary is still without ripe ova (fig. 17) there are no corpuscles in the cells, but nuclei in an active state of division. Each nucleolus or each group of nucleoli, two or even four (figs. 17 and 18, *i*), is surrounded by a clear area. In some there is a small speck of deeply stained chromatin close to the nucleolus (fig. 19).

The epithelial cells (fig. 20, *e*) consist of distinctly reticular protoplasm and stain readily. The largest of the contained corpuscles measures $25\,\mu$ to $30\,\mu$ in diameter. A fully formed corpuscle exhibits a clear outer zone (fig. 20, *d*), $4\,\mu$ in breadth, with a distinct radial striation. This clear outer zone closely surrounds a finely granular contents (*c*) which stains feebly, and lying in it, usually near one side of the corpuscle, a clear vesicular spot (*b*) $5\,\mu$ in diameter, with a bright highly refringent spherule $2{\cdot}5\,\mu$ in its centre (*a*).

These corpuscles have, in point of fact, the closest possible resemblance to the germ-ova of other animals.

The relation of these corpuscles to the nuclei of the containing cells must at present remain a matter of conjecture. It appears to me probable that one of the nuclei of the cells in the young gland, when there are two or more, develops the corpuscle whilst the others remain quiescent. The nuclei both of the young and mature cells stain deeply, whilst the vesicle and highly refractive body in the corpuscle remain unstained.

In several instances I have seen an appearance which leads me to believe that the corpuscles when mature are discharged from the cells in which they are developed into the lumen of the gland (fig. 20). Either empty spaces in the cells or a distinct fissure surrounding the corpuscle which lies close to the lumen of the gland are not uncommon. In some preparations the corpuscles, or some of them, have evidently fallen out in mounting the specimen.

On other occasions I have seen what appears to be a rupture of the clear external zone, and a protrusion of the contents of the corpuscle into the lumen of the gland. There is certainly a close similarity between the contents of these corpuscles and the material which fills the lumen of the gland.

I have, however, been unable to find either the corpuscles themselves or the vesicular body they contain imbedded in this material; but bright refractive nuclear particles like the central highly refringent body of the corpuscles undoubtedly exist in it.

5. *Theoretical Considerations and Conclusions.*

I am led by my observations to the following unexpected conclusions:—

The ovarian eggs in the Blowfly, and probably in other insects, are yelks, and contain no germ.

The so-called gum-glands are in reality germ-glands in which the germ-ova are developed.

These germ-ova pass into the yelks during their passage through the oviducts either (*a*) as naked germinal vesicles, or (*b*) as female pronuclei.

I shall now examine these hypotheses in relation to the work of previous investigators, and discuss their probability.

1. I have already shown that much difficulty exists in attempting to reconcile the observations of previous writers on the development of the ova in insects. So recently as 1881 Prof. Balfour (1) regarded the whole question as unsettled, and contented himself with stating that the relation of the ovum to the germogen and the relation of the yelk-cells to the ovum are points which have been especially controverted. I make this observation to show that the great number of researches which have been recorded by no means settle the question, which therefore still remains an open one.

2. The existence of true germ-ova, if such they are, in what has always been regarded as an accessory gland, although unexpected, is not inconsistent with the probable genetic relations of the Insecta.

Recent embryological observations show that the Insecta exhibit resemblances, sufficiently startling, to the Nemertid worms, and to the Trematodes generally, rather than to the Nematoid worms. This is seen by a comparison of the early developmental stages of *Lineus* (Barrois (2)) and *Chætognatha* (Kowalevski) with those of *Musca*, (Kowalevski, Bütschli), my own unpublished observations being in complete accord with those of the above-named authors.

3. With regard to the structure of the so-called gum-glands of *Musca* and probably of other insects, I would submit that a comparison of the description of the gum-glands, as I have given it, with the ovary of some Arachnids, Crustacea, and Worms is not without interest.

That such ova are developed within cells and present appearances exactly similar to those I have described, is pretty evident from the figures of the young ovary of Spiders given by Stuhlmann (25), plate ix. figs. 190 and 197, and plate x. figs. 214, 215, and 216; whilst similar appearances are represented by Van Beneden (3, 4, and 5) in the germogen of the solid-bodied Worms and some Crustaceans. It is true these authors put a different interpretation on the relation of the ova to the epithelium of the germogen; but the fact remains that their figures are such as to show the close resemblance of the germogen in these animals and the so-called gum-glands of the fly.

4. With regard to the morphology of the gum-gland, so long as we remain ignorant of the precise manner in which this structure and the common oviduct are developed, its morphology will remain more or less doubtful. I have already given my reasons for the belief that the common oviduct is part of the primitive ovary; and this opinion is generally held. The condition of the parts in the Hydrophilidæ is an undoubted indication, I think, that the gum-glands are merely modified ovarian tubules, and have a similar origin from the primitive ovary; the connexion which persists between these glands and the calyx of the ovary in the fly is not, I think, unimportant in this relation. In the Hydrophilidæ the gland is comparable with the germ-gland of the Crustacea. Compare the figures given by Van Beneden (5) and by Stein (24).

It is true that Palmén (21) states that the appendicular glands (the gum-glands and the spermatophorous capsules) have the same origin from the ectodermal invagination as the vagina and uterus; but his observations are general, and he believed the gum-glands to open into the uterus.

5. Supposing my corpuscle to be a germ-ovum, its discharge from the cell in which it is developed may be considered an un-

paralleled phenomenon. I am by no means sure that it is so. The changes in the germarium of the Trematodes described by Van Beneden (5) appear to me to indicate a similar condition. The nature of the germ-ova in these has been discussed with great heat, some holding that the germ is a naked nucleus, and others that it retains a thin, scarcely demonstrable, layer of protoplasm around it.

6. Until the actual passage of such a germ into the yelk has been repeatedly observed, I admit that a serious hiatus exists in my hypothesis. I am far from sure that the phenomenon has not been already observed; at any rate a passage in Leydig's monograph (17) on the ovaries and seminal pouches of insects is worthy of note in this relation. Speaking of the chorion of *Musca domestica*, he says, "this has at the upper pole of the egg a prominent micropyle which appears blocked by a highly refractive corpuscle. The corpuscle is not present in all the eggs, and may be perhaps an exuding yelk-drop "*. I would ask, may it not equally have been an entering germ-yelk?

6. *Bibliography.*

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* "Dieselbe hat am oberen Eipol eine vorstehende Mikropyle und wie verstopft durch ein fettglänzendes Zäpfchen (Taf. iii. fig. 13*b*, 14*b*). Dieses Körperchen ist nicht bei allen Eiern vorhanden und entspricht vielleicht einem herausgetretenen Dottertröpfchen" (*l. c.* p. 35).

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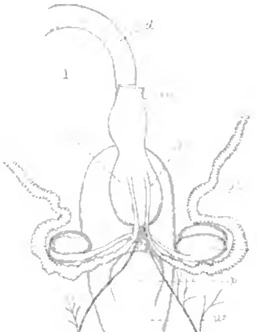

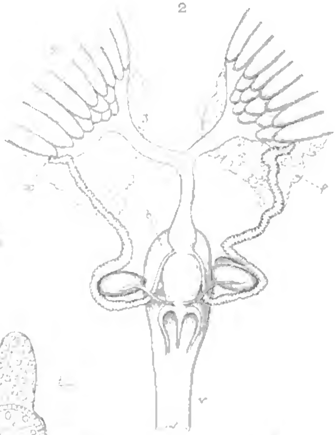

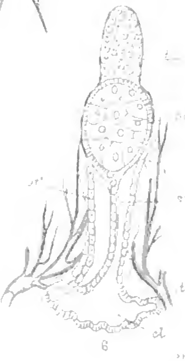

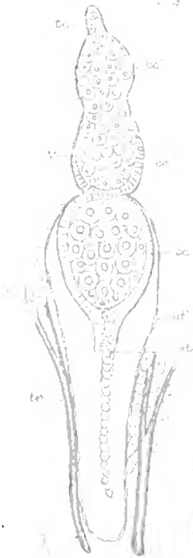

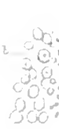

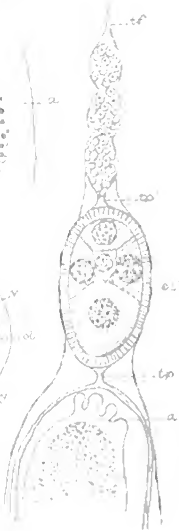

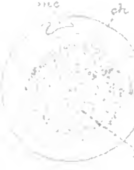

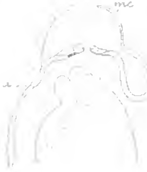

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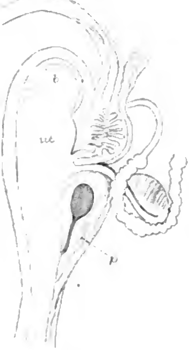

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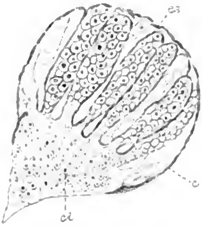

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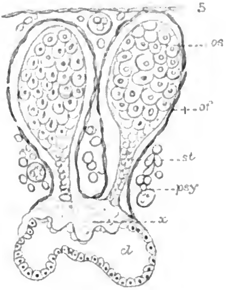

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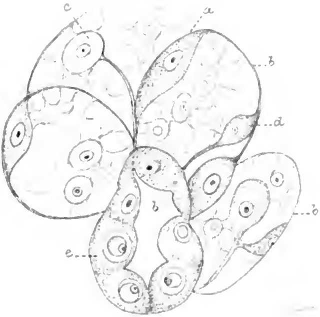

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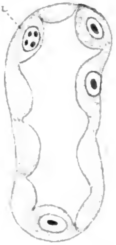

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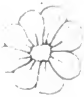

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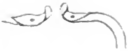

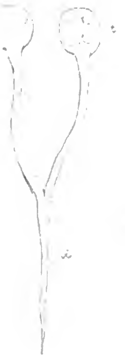

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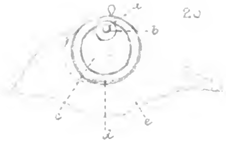

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DESCRIPTION OF PLATE XXVIII.

Figs. 1, 2, and 3. The uterus and its appendages in the adult egg-laying insect. The different parts are indicated by the same letters in all the figures.

b. Bursa copulatrix.
d. Duct of the gum-gland.
gl. Gum-gland.
m. Retractor muscle of oviduct.
o. Ovary.
od. Oviduct.
os. Terminal enlargement of the oviduct.
p. Uterine pouch.
s. Spermatophorous capsule.
ut. Uterus.
v. Vagina.
x. Attachment of the gum-gland to the ovary.

Fig. 1. Dorsal view of the uterus. × 20.

2. The same, with the ovaries. The parts rendered semitransparent with glycerine, and seen by transmitted light. × 10.

3. A median section of the uterus in the vertical antero-posterior plane.

4. The ovary of a three-day-old pupa. *c*, capsule; *cl*, cells of the calix; *es*, egg-strings. × 200.

5. Two of the egg-follicles from a ten-day-old pupa. *cl*, calicine duct; *os*, ovisac; *st*, stalk of egg-follicle of the ovary; *Psy*, pseudo-yelk-granules of the pupa; *x*, cell-mass to which the stalks of the ovisac are attached. × 300.

6. An ovisac from a young fly. *tc*, terminal chamber; *ec*, egg-chamber; *st*, stalk of ovarian follicle; *cl*, calicine duct; *tr*, trachea. × 200.

7. Another ovisac from a young fly, a little more advanced. *y*, edge of epithelium of egg; *ec'*, *ec''*, young egg-chambers. The other letters as in figs. 5 and 6. × 300.

Fig. 8. The egg-follicle from the ovary of a mature egg-laying insect. × 200.
9. Transverse section of an egg. *mc*, micropyle canal; *ch*, chorion; *v*, vitelline membrane; *cl*, clear yelk; *y*, granular yelk. × 30.
10. A longitudinal section of an egg. *mc'*, chamber at anterior pole of the egg; *m*, micropyle.
11. A section of the yelk. *a*, clear margin; *b*, granular yelk. × 400.
12. The micropyle. × 400.
13. A section through the micropyle. × 400.
14. The testes of a larval blowfly, showing the union of the prolongations from which the duct is developed: after Weismann.
15. The gum-gland and some of the adjacent fat-body. *l*, lumen of the gum-gland; *e*, epithelium of gum-gland; *bb*, capsule of fat-cells; *a*, *c*, *d*, stellate and flask-shaped cells enclosed within the capsule. × 200.
16. Transverse section of the gum-gland of the mature insect.
17. Transverse section of the gum-gland of the immature insect.
18, 19, 20. Epithelial cells from the gum-gland, with the contained corpuscles and nuclei in different stages of development.

On the Deep-water Fauna of the Clyde Sea-area. By William E. Hoyle, M.A. (Oxon.), F.R.S.E., Keeper of the Manchester Museum. (Communicated by John Murray, LL.D., Ph.D., V.P.R.S.E., F.L.S.)

[Read 4th April, 1889.]

(With Map: Plate XXIX.)

Since the establishment of the Scottish Marine Station in the year 1884, Dr. John Murray has conducted an extensive series of dredgings in the greater number of the lochs of the west coast of Scotland. During these operations he was struck, as Forbes had been before him, with the restricted distribution of certain forms, as well as with the fact that some species occurred nowhere off the British shores except in these depressions.

In the summer of last year, Dr. Murray suggested that I should continue these investigations, and endeavour to render them as complete as possible during the months of July and August, offering at the same time to give me the use of the steam-yacht 'Medusa' for dredging and trawling, and to allow me the use of the materials which he had already accumulated.

Circumstances fortunately allowed of my accepting this offer, and during the two months just mentioned I made Millport, on the Island of Cumbrae, my headquarters, and thence made excursions to all the different parts of what is now known as the "Clyde sea-area."

The physical configuration of this region has been very ably described by Dr. Hugh R. Mill *, whose communication is illustrated by an admirable orographical and bathymetrical chart. He regards the "Clyde sea-area" "as bounded on the south by a line drawn from the Mull of Cantyre to Corsewell Point in Wigtownshire, almost coinciding with the contour of 50 fathoms;" and within it he defines seven deep-water basins, which have a depth exceeding 20 fathoms, and are separated from each other by ridges, considerably shallower than the extreme depths of the basins themselves.

1. The *Arran* Basin extends on either side of the north of Arran, and up into lower Loch Fyne, being in shape like the letter λ. In the sequel I have regarded it as subdivided into four portions, which may be termed respectively the "Brodick," "Cumbrae," "Kilbrennan," and "Inchmarnoch" basins.

The last of these is the deepest, and, indeed, attains the greatest depth found anywhere in the Firth, namely 107 fathoms off Skate Island. The Kilbrennan and Inchmarnoch Basins are not so distinctly marked off from each other as are the remaining ones, the channel which unites them just reaching the 60-fathom line, the extreme depth of the former being 85 fathoms. The Brodick basin, which is off the bay of the same name, has a depth of 92 fathoms, whilst the Cumbrae basin descends only to 62 fathoms.

2. *Upper Loch Fyne* is 25 miles in length, and has a depth of about 80 fathoms off Strachur.

3. *Loch Striven* runs up into the mainland due north of Rothesay, and attains a depth of a little over 40 fathoms.

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* Scottish Geogr. Mag. iii. pp. 1-7 (1887).

4. The *Dunoon* Basin occupies the channel of the river from the extremity of Great Cumbrae northwards, and extends up into the lower stretch of Loch Long. Its greatest depression off Dunoon is 56 fathoms.

5. *Loch Goil* is only about 4 square miles in area, and its extreme depth is 47 fathoms.

6. *Upper Loch Long* is of about the same extent, but has a depth of only 35 fathoms.

7. The *Gareloch* has an area of about 5 square miles, and is 23 fathoms in depth.

The object which I set before myself was to ascertain as fully as possible the fauna of each of these depressions, limiting them by the contour-line of 20 fathoms, and then with all the materials available to draw up comparative lists, and to endeavour to discover their relations to each other.

Unfortunately I have been unable to make much use of the published works of my predecessors, owing to the form in which their results are stated. "Fairly common in depths of 5–25 fathoms," with a few localities appended, is the type of a phrase which occurs continually, but is, for the purposes of the present inquiry, quite useless. The cases in which I have drawn information from sources other than the records of the Scottish Marine Station are all indicated.

The specimens collected by Dr. Murray had been sent from time to time to the British Museum, and he had received from the authorities of that institution lists of these consignments, along with a number of named duplicates, which were of great help in the identification of my own subsequent acquisitions. I have to acknowledge, with my sincerest thanks, the assistance I have received, not only from the staff of the British Museum, but from several other friends. Mr. David Robertson and the Rev. Canon Norman, whose extensive knowledge of the British marine fauna is well known, were at Millport during the greater part of my stay there, and I had thus the advantage of being able to consult them constantly. Messrs. Isaac C. Thompson and W. S. M'Millan, of Liverpool, have been good enough to draw up lists of the Copepoda for me, and Prof. Herdman has given me the benefit of his acquaintance with the Tunicata. To Dr. John Murray, as above stated, I owe the suggestion of the present investigation, as well as the means of carrying it out.

Before proceeding to enumerate the species obtained, it seems advisable to say a few words regarding the mode of procedure adopted in collecting, for this probably explains certain general features in the results obtained. In the great majority of instances the instrument employed was a shrimp-trawl, which was found on the whole more convenient for working in these localities than the dredge, owing to its bringing up a less amount of mud and a greater variety of forms. Certain groups, such as the Mollusca, are not obtained in such large numbers as by the dredge, and hence the list of these animals obtained is small as compared with that known to inhabit the district.

A tow-net was generally attached a short distance above the trawl, so as to capture any Crustaceans which might be swimming just above the bottom. These were almost invariably found to be of a different species from those taken in the nets which were dragged at the surface.

STATEMENT OF RESULTS.

For convenience I have drawn up the results in the form of a Table, with a column corresponding to each basin. The figures show the range in fathoms in that particular region, whilst there is appended in another column a sketch of the distribution of each form outside the British area. Those facts which have been taken from the published writings of others are indicated by italics. A note of interrogation indicates that I have obtained the species in that locality, but the record of the exact depth has been lost. *d* means that dead shells, not living specimens, were obtained.

	Arran Basin.				Upper Loch Fyne.
	Brodick Basin.	Kil-brennan Basin.	Inch-marnoch Basin.	Cumbrae Basin.	
Pisces.					
1. Pristiurus melanostomus (*Bonap.*)	......	......	......	......	37
2. Acanthias vulgaris, *Risso*	......	26	......	......	38
3. Raja clavata, *L.*	......	26	......	......	......
4. —— fullonica, *L.*	......	20	100	......	......
5. —— maculata, *Montag.*	......	......	......	......	......
6. Lophius piscatorius, *L.*	70	......	......	......	......
7. Cottus bubalis, *Euphr.*	......	60	......	......	......
8. —— Lilljeborgii, *Collett*	15–30	......	......	......	......
9. —— scorpius, *L.*	......	......	......	......	......
10. Trigla gurnardus, *L.*	80–90	26–46	......	......	......
11. Triglops Murrayi, *Gthr.*	......	64	......	......	......
12. Agonus cataphractus, *L.*	......	20-64	......	......	......
13. Liparis liparis (*L.*)	......	49–64	......	......	......
14. Gobius Jeffreysii, *Gthr.*	......	20–45	......	56	......
15. —— minutus, *Gm.*	50–60	26	37	......	50
16. Callionymus lyra, *L.*	......	26	......	......	......
17. —— maculatus, *Raf.*	......	26	......	......	......
18. Centronotus gunellus (*L.*)	......	20	......	......	......
19. Stichæus lampetræformis	......	......	......	60	......
20. Gadus æglefinus, *L.*	......	26	90	......	......
21. —— luscus, *L.*	90	......	......	......	......
22. —— Esmarkii, *Nilss.*	......	26–65	80	......	......
23. —— merlangus, *L.*	50–60	26–46	90	56	......
24. —— minutus, *L.*	......	65	......	56	37
25. —— morrhua, *L.*	......	26	......	......	......
26. Merluccius merluccius (*L.*)	......	26	80	......	......
27. Molva molva (*L.*)	......	......	......	......	......
28. Onus cimbrius (*L.*)	30–90	46	70–100	56	37
29. —— maculatus (*Risso*)	......	65	40	......	......
30. Hippoglossoides limandoides (*Bl.*)	......	40	45-100	......	......
31. —— platessoides (*Fabr.*)	30-60	26–46	80–100	......	30
32. Rhombus megastoma (*Donov.*)	......	40	......	......	......
33. —— norvegicus, *Gthr.*	......	45	......	......	......
34. —— punctatus (*Bl.*)	......	......	......	60	......
35. Pleuronectes cynoglossus, *L.*	......	46–70	80–100	......	......

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	......	......	......	......	"Seas of Europe, being common in the Mediterranean."
......	......	......	......	......	Temperate seas of Northern and Southern hemispheres.
......	......	......	......	......	Around the seas of Europe, Medit.
......	......	......	......	......	Western Europe, rare in Medit., Madeira.
......	30–40	......	......	......	European coasts to Medit.; Madeira.
......	30–40	......	......	......	Rare north of 60° N., Medit. to Cape of Good Hope; Newfoundland to Cape Hatteras.
......	......	......	......	......	Arctic regions in both hemispheres; Baltic, North Sea, France, Spain.
......	......	......	......	......	Norway and Færoes (new to Britain).
......	15–30	......	......	......	Arctic and N. Atlantic in both hemispheres; Baltic, North Sea.
......	......	......	......	......	Baltic; West Europe from Norway to Medit.
......	......	......	......	......	New species; an arctic genus.
......	......	......	......	......	Iceland, Norway, Baltic, German Ocean.
......	30–40	......	......	......	Polar Regions to Cape Cod, and to Scandinavia, Denmark, Holland, France. ? Mediterranean.
......	43	......	......	......	Shetland, Medit.
40	20–43	45	......	20	Scandinavia, Shetland, Channel, Medit.
......	......	......	......	......	Norway, Denmark, German Ocean, very rare in Medit.
......	......	......	......	......	Scandinavia, Denmark, Shetland, Medit. (new to Britain).
......	......	......	......	20	Greenland, Iceland, Shetland to France.
30–40	20	......	40	20	Iceland, Scandinavia.
......	30–40	40	......	......	Northern and Arctic Europe, Newfoundland to Cape Hatteras.
... ..	......	......	......	......	Scandinavia to Medit.
......	......	......	......	......	Scandinavia, Færoes (new to Britain).
......	30-40	......	......	......	Scandinavia to Medit.
......	......	......	......	......	Scandinavia to Medit.
......	40	......	......	......	Northern seas of Europe and America.
30–40	30–40	......	40	20	Scandinavia to Madeira and Medit., Greenland to Cape Hatteras.
......	30-40	......	......	......	Spitzbergen to Medit.
30–40	20–40	......	......	......	Coasts of Northern Europe.
......	.....	......	......	......	Coasts of Europe.
......	40–42	......	......	......	Coasts of Northern Europe.
30–40	20–40	40	40	20	North Atlantic.
......	......	......	......	......	Northern seas to French coast.
......	43	......	......	......	Sweden and Norway.
......	......	......	......	......	Northern Europe to France.
......	30–40	......	40	......	North Sea to France, American coast.

	ARRAN BASIN.				Upper Loch Fyne.
	Brodick Basin.	Kilbrennan Basin.	Inchmarnoch Basin.	Cumbrae Basin.	
36. Pleuronectes flesus, *L.*	......	......	......	......	......
37. —— limanda, *L.*	......	20	......	......	......
38. —— microcephalus, *Donov.*	50–60	......	40–60	......	......
39. —— platessa, *L.*	......	26	......	......	......
40. Solea variegata (*Donov.*)	......	65	......	......	......
41. Argentina sphyræna, *L.*	......	......	......	......	......
42. Conger vulgaris, *Cuv.*	......	......	......	56	......
42 species.					
TUNICATA.					
43. Cynthia echinata, *Linn.*	?	?	80-104	......	......
44. Styela grossularia, *V. Ben.*	50–60	?	80-104	......	70
45. —— rustica, *Linn.*	......	......	80-100	......	70
46. Polycarpa pomaria, *Sav.*	......	......	?	......	......
47. Corella parallelogramma, *O. F. Müll.*	?	?	?	......	50
48. Ciona intestinalis, *Linn.*	?	?	?	......	50
49. Ascidia mentula, *O. F. Müll.*	......	?	45–49	......	70
50. —— scabra, *O. F. Müll.*	?	?	45–104	......	......
51. —— virginea, *O. F. Müll.*	?	?	80–100	......	......
9 species.					
MOLLUSCA.					
52. Eledone cirrosa, *Lamk.*	......	22	......	......	......
53. Sepiola Rondeleti, *Leach*	......	22–70	......	......	......
54. Rossia Oweni, *Ball*	28–90	22–49	......	......	30-65
55. Dendronotus arborescens (*Müll.*)	......	40–49	......	......	......
56. Scaphander lignarius (*L.*)	......	22	......	......	......
57. Pleurotoma (Bela) turricula (*Mont.*)	......	......	45–49	50	......
58. Chrysodomus antiquus (*L.*)	50–90	22–70	37–104	60–62	50
59. Fusus (Sipho) gracilis (*Da C.*)	22	22	100	60–62	50
60. Buccinum undatum, *L.*	......	22-70	104 *d.*	......	50–70
61. Aporrhais pes-pelecani (*L.*)	......	22	37–49	60–62	......
62. Turritella terebra (*L.*)	50–90	22	37–49	50	......
63. *Rissoa abyssicola*, Forbes	......	......	*100*	......	......
64. Velutina lævigata (*Penn.*)	......	......	104	......	50
65. Natica Alderi, *Forbes*	......	......	80	......	......
66. —— Montagui, *Forbes*	60	......	104	60–62	......
67. —— sordida, *Phil.*	90	22	37–104 *d.*	60-62	......
68. Trochus (Gibbula) cinerarius, *L.*	......	......	45–49, 104 *d.*	50	30–75
69. —— magus, *L.*	......	......	45–49 *d.*	......	......
70. —— (Zizyphinus) zizyphinus, *L.*	......	40–64	......	......	......
71. —— (——) millegranus, *Phil.*	......	40–49	104	......	30–35 *d.*
72. Emarginula crassa, *Sow.*	......	......	104 *d.*	......	......

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	......	......	......	20	Iceland, Northern Europe to France.
......	......	......	......	......	Iceland, Northern Europe to Bay of Biscay.
......	40	......	......	20	Iceland to France; Kamtschatka.
......	30–40	......	30	......	Iceland to France; rare in Medit.
......	......	......	......	......	Britain to France and Medit.
37	32	......	......	......	Norway to Medit.
......	......	......	......	......	Europe, Medit., East Indies, Japan, Tasmania.
......	......	......	......	......	Greenland, Spitzbergen, to Britain; [U.S.A.
......	......	......	30	......	Arctic to Belgium; U.S.A.(?)
......	......	......	......	......	Arctic to Britain; U.S.A.
......	40	35	......	......	Scandinavia to Medit.
......	......	35	......	......	Scandinavia to Britain.
......	......	......	......	......	Arctic to Medit.; Australia.
......	40	30–40	......	......	Greenland, Iceland, Scandinavia to Britain; U.S.A.?; Medit.
......	......	......	......	......	Scandinavia to Medit.
......	......	......	......	.. ...	Scandinavia to Medit.
......	......	......	......	......	Scandinavia to Medit.
......	30–40	......	......	......	Greenland to Scandinavia and Medit.; W. Africa, Canaries.
40	30–40	35-40	......	......	Scandinavia to Britain.
......	......	......	......	......	Arctic.
......	......	......	......	......	All European seas. 1–50 fms.
40	42	......	......	......	Arctic and Boreal Europe and U.S.A. [3–100 fms.
......	30–42	35–40	30	20	Arctic and Boreal to France. [5–30 fms.
30–44	30–40	35–40	30	......	Boreal Europe to Bay of Biscay, and U.S.A. 5–80 fms.
30–40	30–42	30–40	30	20	Celtic and Boreal Europe, Greenland and U.S.A. Low water to 100 fms.
30–40	30–40	......	......	20	All European coasts, Medit. [3–100 fms.
......	30–40	......	......	......	Boreal and Celtic. 7–100 fms.
......	......	......	......	......	Scandinavia to Medit. Deep-water.
. ....	......	35	......	......	Arctic and Boreal. Isle of Man. [Shallow water to 30 fms.
......	......	......	......	......	Atlantic and Medit.
......	30–42	......	......	......	Celtic Region. 12–90 fms.
......	......	45	......	......	Medit. and Atlantic. 20–60 fms.
30–40	40	30–35	30	......	Norway to Spain. Shallow water to [20 fms.
......	......	......	......	......	Britain to Medit. 3–25 fms.
......	......	......	......	......	Norway to Medit. Low water to 50 fms.
......	30–40	......	......	......	Norway to Medit. 15–100 fms.
......	......	......	......	......	Norway. 20–25 fms.

	Arran Basin.				Upper Loch Fyne.
	Brodick Basin.	Kil-brennan Basin.	Inch-marnoch Basin.	Cumbrae Basin.	
73. Emarginula reticulata, *Sow.*	......	......	104 *d.*	......	......
74. Puncturella Noachina (*L.*)	......	......	104	......	50
75. *Tectura fulva* (Müll.)	......	......	......	......	......
76. Chiton marginatus, *Penn.*	......	......	104	......	50
77. Dentalium entalis, *L.*	90	......	37–104	......	70–75
78. Anomia ephippium, *L.*	22–50	......	37	......	......
79. —— patelliformis, *L.*	......	40–49	......	......	75
80. Lima elliptica, *Jeffr.*	50–90	......	80	......	......
81. Pecten maximus (*L.*)	......	.....	45–49	......	......
82. —— opercularis (*L.*)	22	22–64	37–49	60–62	30–75
83. —— pusio (*L.*)	50–60 *d.*	65	......	......	70
84. —— septemradiatus, *Müll.*	50–90	22–70	37–104	60–62	30–80
85. —— striatus, *Müll.*	80–90	......	37	60–62	......
86. —— tigrinus, *Müll.*	......	......	45–49	......	......
87. Modiola modiolus (*L.*)	......	40–49	......	......	......
88. —— barbata (*L.*)	......	......	......	......	70–75
89. Modiolaria marmorata (*Forbes*)*	......	......	.....	......	......
90. Nucula nitida, *Sow*	50–60	40	45–104	50	......
91. —— nucleus (*L.*)	50–60	......	......	......	.....
92. —— sulcata, *Bronn*	80–90	22–70	37–104	50	......
93. —— tenuis (*Mont.*)	......	......	80–104	......	......
94. Leda minuta (*Müll.*)	......	22	45–104	......	.. ...
—— ——, f. brevirostris, *Jeffr.*	......	......	......	......	......
95. Astarte compressa (*Mont.*)	......	......	......	......	36
96. —— elliptica, *Brown*	50–60	......	37	......	......
97. —— sulcata (*DaC.*)	50–60 *d.*	70	104	......	50
98. Cardium aculeatum, *L.*	......	22	......	......	......
99. —— echinatum, *L.*	......	......	37	.....	......
100. —— fasciatum, *Mont.*	... ..	......	......	60–62	......
101. —— minimum, *Phil.*	......	......	104	......	......
102. Cyprina islandica (*L.*)	......	65	37	......	......
103. Isocardia cor (*L.*)	50–60	......	......	......	......
104. Dosinia exoleta (*L.*)	......	......	45–49 *d.*	......	......
105. —— lincta (*Pult.*)	......	......	37, 45–49 *d.*	......	......
106. Venus fasciata (*DaC.*)	......	40–49	37	......	......
107. —— ovata, *Penn.*	50–60	......	37–49	......	......
108. Cryptodon ferruginosus (*Forbes*)	70	......	......	......	......
109. —— flexuosus (*Mont.*)	......	......	......	......	......
110. —— croulinensis (*Jeffr.*)	70	......	......	......	......
111. Solen pellucidus, *Penn.*	......	......	......	......	......
112. Mactra elliptica, *Brown*	......	......	45–104	......	......

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* This form is. of course, only found along with the Ascidian on which it is parasitic.

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	......	......	......	......	All West Europe, Medit. 12–90 fms.
......	......	......	......	......	Greenland, North Atlantic, U.S.A., and Japan. 20–100 fms.
......	*20–30*	......	......	......	Norway. 20–80 fms.
......	......	......	......	......	Scandinavia, U.S.A., Vigo Bay. [Shallow.
......	......	35	......	......	Norway to Spain. 40–70 fms.
......	42	......	......	......	All European seas. Low water to [30 fms.
......	......	......	......	......	Northern Europe to Medit. 45–50 fms.
......	......	45	......	......	All European coasts. 15–20 fms.
......	......	......	......	......	Norway to Gibraltar and Medit. [3–40 fms.
40	30-40	......	......	......	All European seas. 5–100 fms.
......	......	......	......	......	All European seas. Low water to [90 fms.
30-40	30–40	35-45	......	......	Scandinavia, Medit. 20–100 fms.
......	......	......	30	......	Boreal, very rare in Medit. 12–60 fms.
......	......	......	......	......	Atlantic and N. European seas. [12–60 fms.
......	......	......	......	......	N. Atlantic. Low water to 70 fms.
......	......	......	......	......	Lusitanian Region, Medit. 3–10 fms.
......	......	......	......	......	All European seas. Parasitic on *Ascidia mentula*. Low water to 40 fms.
30-40	30–42	35	30	20	Sweden, Lusitania, Medit. Shallow [water to 34 fms.
......	......	......	......	......	All European seas. Common. [7–90 fms.
30–40	30–42	45	......	......	Scandinavia to Medit. (deep). [30–100 fms.
......	30–40	......	......	......	Northern Europe, and U.S.A. [40–100 fms.
.....	......	35-45	......	......	Arctic and Scandinavia. 10–100 fms.
......	40				
......	......	......	......	......	Norway. 7–70 fms.
......	......	......	......	......	Greenland, Norway. 10–45 fms.
......	......	......	......	......	All European seas. 8–80 fms.
......	......	......	......	......	Scandinavia to Medit.
......	......	......	......	......	Scandinavia to N. Atlantic. 7–80 fms.
......	......	......	......	......	Atlantic.
......	......	......	......	......	Arctic and Norway. 30–70 fms.
......	......	......	......	......	Northern Europe. 5–80 fms.
......	......	......	......	......	Scandinavia to Medit. 15–40 fms.
......	......	......	......	......	All European seas. [Low water to 80 fms.
......	......	......	......	......	All European seas. [Low water to 60 fms.
......	......	......	......	......	Norway to Medit. 4–60 fms.
......	......	......	......	......	Norway to Medit. 3–100 fms.
......	......	*25*	......	......	Arctic to Medit. 20–100 fms.
......	......	40	......	......	Arctic to Medit. 3–80 fms.
......	......	......	......	......	Arctic, Atlantic, and Medit.
......	......	......	......	20	Throughout European seas. 6–100 fms.
......	......	......	......	......	Arctic and N. Atlantic. [Low water to 50 fms.

	Arran Basin.				Upper Loch Fyne.
	Brodick Basin.	Kil-brennan Basin.	Inch-marnoch Basin.	Cumbrae Basin.	
113. Mya truncata, *L.*	......	......	......	......	50 *d.*
114. Corbula gibba, *Olivi*	50-60	22	......	50	36
115. Saxicava rugosa (*L.*)	50	......	......	......	......
116. Tellina sordida	......	......	45-49	......	......
117. Semele (Abra) alba (*Wood*)	90	......	37-80	50	36-50
118. —— nitida, *Müll.*	......	......	80	......	......
119. —— tenuis (*Mont.*)	......	......	......	......	......
120. Cuspidaria abbreviata, *Forbes*	......	......	30	......	......
121. —— cuspidata (*Olivi*)	......	......	......	......	......
70 species.					
BRACHIOPODA.					
122. Terebratulina caput-serpentis (*L.*).	......	......	80-104	......	50
1 species.					
POLYZOA.					
123. Scrupocellaria reptans (*L.*)	......	64	......	......	......
124. Bugula turbinata, *Alder*	......	30-50	......	......	......
125. Cellaria fistulosa (*L.*)	......	25-64	......	......	......
126. Flustra foliacea (*L.*)	......	25-49	......	......	......
127. —— securifrons (*Pallas*)	......	65	......	......	......
128. Membranipora catenularia (*Jameson*).	......	50	......	......	......
129. —— Flemingi, *Busk*	......	65	......	......	......
130. —— pilosa (*L.*)	......	50	104	......	......
131. Microporella ciliata (*Pall.*)	......	50	......	......	......
132. —— impressa (*Aud.*)	......	50	......	......	......
133. Schizoporella unicornis (*Johnst.*)	......	25	......	......	......
134. Hippothoa carinata, *Norman*	......	50	......	......	......
135. Porella compressa (*Sow.*)	......	25	......	......	......
136. Smittia reticulata (*MacGill.*)	......	25	......	......	......
137. Mucronella Peachii (*Johnst.*)	......	25-64	......	......	......
138. —— ventricosa (*Hass.*)	......	50	......	......	......
139. Cellepora avicularis, *Hincks*	......	50-65	......	......	......
140. —— pumicosa, *L.*	......	50	......	......	......
141. —— ramulosa, *L.*	......	25-64	......	......	......

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	......	......	......	......	Arctic and Atlantic. [Shallow water to 34 fms.
40	40	30-35	30	......	All European seas. 7 to 80 fms.
......	......	......	......	20	Boreal and Celtic regions, N. Spain. [Shallow.
......	......	......	......	......	Arctic. 53 fms.
30–40	30-42	35-45	30	20	Scandinavia to Medit. [Common 1-40 fms.
......	......	......	......	......	Norway to Medit.
......	......	40	......	......	Britain to Medit.
......	......	......	......	......	Norway, Medit. 40-200 fms.
30–40	......	......	......	......	Norway, Sweden, Medit. 12-185 fms.
......	......	......	......	......	All European seas, U.S.A. 10-90 fms.
......	......	......	......	......	Scandinavia to Medit., Red Sea (?). [To 100 fms.
......	......	......	......	......	British only. Shallow.
......	......	......	......	......	Scandinavia to Medit., U.S.A., Madeira, Indian Ocean, N. Zealand. [40-140 fms.
......	......	......	......	......	Norway to Medit., S. Africa, China, Pacific. To 70 fms.
......	......	......	......	......	Spitzbergen to Medit., Labrador. [10-300 fms.
......	......	......	......	......	North Sea to Medit., U.S.A. [40–300 fms.
......	......	......	......	......	Greenland to Medit. ["Tide-marks to deep water."
......	......	......	......	......	Greenland and Norway to Medit., U.S.A., Indian Ocean, N. Zealand. [Low water to 100 fms.
......	......	......	......	......	Cosmopolitan. 0-145 fms.
......	......	......	......	......	Norway to Medit. 30-40 fms.
......	......	......	......	......	Greenland to Medit., U.S.A., S. Africa.
......	......	......	......	......	Antrim, Birterbuy Bay. [30-170 fms.
......	......	......	......	......	Arctic to N. France. 40-170 fms.
......	......	......	......	......	Norway to Medit., Falkland Is., N. Zealand. 40-80 fms.
......	......	......	......	......	Greenland and Norway to Medit., U.S.A. Low water to 170 fms.
......	......	......	......	......	Arctic, Norway to Medit., N. Zealand. [10-20 fms.
......	......	......	......	......	Spitzbergen, Scandinavia, Medit., U.S.A.
......	......	......	......	......	Cosmopolitan. 5-50 fms.
......	......	......	......	......	Norway to N. France, Madeira. [8-170 fms.

	Arran Basin.				Upper Loch Fyne.
	Brodick Basin.	Kil-brennan Basin.	Inch-marnoch Basin.	Cumbrae Basin.	
142. Crisia denticulata (*Lamk.*)	......	64	......	......	......
143. —— eburnea (*L.*), *var.* aculeata	......	50	......	......	......
—— ——, *var.* producta.........	......	25	......	......	......
144. Stomatopora granulata (*M.-Edw.*).	......	65	......	......	......
145. Idmonea serpens (*L.*)	......	65	......	......	......
146. Diastopora obelia, *Johnst.*	......	50–64	......	......	......
147. Lichenopora hispida (*Flem.*) ...	......	25–64	......	......	......
—— ——, *var.*mæandrina,*Peach*	......	65	......	......	......
148. —— verrucaria (*O. Fabr.*)	......	50	......	......	......
149. Mucronella ventricosa	......	50	......	......	......
150. Vesicularia spinosa (*L.*)	......	50	......	......	......
151. Cylindrœcium dilatatum, *Hincks.*	......	65	......	......	......
29 species.					
Crustacea.					
152. Inachus dorsettensis, *Penn.* ...	......	......	37–104	50–60	50
153. —— dorynchus, *Leach*	......	25	......	......	......
154. Hyas araneus, *L.*	......	......	......	......	50
155. —— coarctatus, *Leach*	60	49–65	45–49	60	75–80
156. Stenorhynchus longirostris, *M.-Edw.*	......	40–49	37	50	......
157. —— rostratus, *L.*	......	40–64	......	......	......
158. Eurynome aspera, *Penn*..........	......	......	......	50	......
159. Portunus depurator, *L.*	80–90	?	104	50–60	......
160. —— holsatus, *Fabr*...............	......	......	45–49	......	......
161. —— marmoreus, *Leach*	......	......	......	......	......
162. —— pusillus, *Leach*..............	......	......	104	......	......
163. Ebalia tuberosa, *Penn*............	......	......	......	50	......
164. Lithodes maia (*L.*)	......	?	37–49	......	70
165. Eupagurus bernhardus (*L.*) ...	......	20–49, *80*	37–104	50–60	35–70
166. —— Prideauxii (*Leach*)	......	50	......	50–60	......
167. —— pubescens (*Kröyer*).........	......	20–65	......	60	......
168. —— excavatus, *Miers*	......	......	45–49	......	......
169. Anapagurus lævis (*Thompson*)	......	?	37–104	60	......
170. Galathea dispersa, *Sp. Bate* ...	50–90	......	......	......	......
171. —— nexa, *Embleton*	50–60	......	......	......	......
172. —— squamifera, *Leach*	......	49	......	......	80
173. Munida rugosa (*Fabr.*)	80–90	70	......	......	......
174. Calocaris Macandreæ, *Bell*	50–90	......	80–104	50	......
175. Nephrops norvegicus (*L.*)	80–90	40	37	......	......
176. Crangon Allmani, *Kinahan* ...	25–90	20–70	37–80, *105*	40–62	50–75
177. —— echinulatus, *M. Sars*	......	.....	104	......	......
178. —— spinosus, *Leach*	......	......	45–49	......	......
179. Nika edulis, *Risso*	*93*	.. ...	*104*	......	......
180. Hippolyte Gaimardi, *M.-Edw.* .	......	......	45–104	......	50–75
181. —— pusiola, *Kröyer*	......	......	......	.. ...	......
182. —— securifrons, *Norman*	50–90	50–60	37–80	60–70	35–80
183. —— spinus, *Sowb.*	......	65	......	......	......

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	......	......	......	......	Arctic to Medit., U.S.A., Madeira, S. Africa. [10–100 fms.
......	......	......	......	......	All British shores. 4–96 fms.
......	......	......	......	......	Nova Zembla, Scandinavia.
......	......	......	......	... ..	Norway to N. France. [Low water to 170 fms.
......	......	......	......	......	Norway to Medit. [2 fms. to "deep water."
......	......	......	......	......	Arctic and Norway to Medit., U.S.A. [2–20 fms.
......	......	......	......	......	Greenland and Norway to S.W. France. , To 170 fms.
......	......	......	......	......	Shetland. 80–100 fms.
......	......	......	......	......	Arctic, Norway, U.S.A. 10–150 fms.
......	......	......	......	......	Arctic, Scandinavia, to Medit., New Zealand.
......	......	.. ...	......	......	Norway to N. France.
......	......	......	......	......	Belgium to Medit. 8–? fms.
......	30–40	......	......	......	Norway, Medit., Atlantic.
......	......	......	......	......	Norway, Medit., Atlantic.
......	30–40	......	......	......	Norway, Labrador, U.S.A.
......	30–42	......	30	20	Norway, Labrador, Arctic, U.S.A.
......	......	......	......	...	Medit., Atlantic.
......	......	......	......	......	Norway.
......	......	......	......	......	Norway, Medit. 25–35 fms.
......	30–42	30	30	20	Norway, Medit.
......	......	......	......	......	Norway, Medit.
......	......	......	......	20	N. Atlantic to Medit.
......	......	......	......	......	Norway, Medit., Canaries.
......	......	......	......	......	Norway, Medit.
......	......	40–45	30	......	Norway, U.S.A. Shallow.
40	30–12	30–40	30	20	Norway, Medit., U.S.A.
......	30–40	......	......	......	Norway, Medit., Cape Verde.
......	......	......	......	......	Norway, Labrador, Arctic, U.S.A.
......	......	......	......	......	Medit., Atlantic, Senegambia.
......	......	......	......	......	Norway, Medit.
......	......	......	......	......	Norway.
......	*20–40*	......	......	......	Norway, Medit.
......	......	......	......	......	Norway, Medit.
40	30–40	30–40	......	......	Norway, Medit.
......	*40*	......	......	......	Norway, Medit., U.S.A.
40	30–42	45	......	20	Norway, Medit.
40	30–42	30–45	30	20	Norway.
......	......	......	......	......	Norway.
......	42	......	......	......	Norway, Medit.
......	......	......	......	......	Norway, Medit.
40	30–42	30–35	30	20	Norway, Labrador, Arctic, U.S.A.
......	......	20–35	20–35	......	Norway, U.S.A.
40	30–42	30–45	......	20	Norway, U.S.A.
......	......	......	......	......	Norway, Labrador, Arctic, U S.A.

	Arran Basin.				Upper Loch Fyne.
	Brodick Basin.	Kilbrennan Basin.	Inchmarnoch Basin.	Cumbrae Basin.	
184. Caridion Gordoni (*Sp. Bate*)	......	50-60	......	......	......
185. Pandalus annulicornis, *Leach*	45-90	20-70	45-100	46-70	60-70
186. —— brevirostris, *Rathke*	......	......	37	......	......
187. Pasiphæa sivado (*Risso*)	50-90	49	*104*	......	......
188. Nyctiphanes norvegica (*M. Sars*)	50-90	......	80-100	......	60-75
189. Boreophausia inermis (*Kröyer*)?	......	......	......	......	......
190. —— Raschi (*M. Sars*)	......	......	......	60	......
191. Mysidopsis didelphys (*Norman*)	......	......	......	......	......
192. Mysis neglecta, *G. O. Sars*	......	......	*60*	......	......
193. Cirolana hirtipes, *M.-Edw.*	......	......	37-80	*29*	......
194. Conilera cylindracea (*Mont.*)	......	......	......	*50*	......
195. Munna whiteana, *Sp. B. & W.*	......	......	......	*35-40*	......
196. Janira maculosa, *Leach*	......	......	*40-60*	......	......
197. Arcturus longicornis (*Sowb.*)	......	49	*105*	*20*	......
198. Idotea parallela, *Sp. B. & W.*	......	......	......	*50*	......
199. Hippomedon Holbölli (*Kröyer*)	......	......	*80*	......	......
200. Tryphosa longipes (*Sp. Bate*)	......	......	......	*66*	......
201. Callisoma crenatum (*Sp. Bate*)	......	......	*80*	*30*	......
202. Bathyporeia pilosa (*Lindstr.*)	*20*	......	......	......	......
203. Lysianax tumida (*Kröyer*)	......	......	*40-60*		......
204. Leucothoë spinicarpa (*Abild.*)	......	......	*92*	......	......
205. Stenothoë monoculoides (*Mont.*)	......	......	......	*40?*	......
206. Harpinia plumosa (*Kröyer*)	......	......	*80*	......	......
207. Westwoodilla cæcula, *Sp. Bate*	......	*20*	......	......	......
208. Monoculodes Stimpsoni, *Sp. Bate.*	......	......	*105*	......	......
209. —— longimanus, *Sp. B. & W.*	*20*	......	......	......	......
210. Epimeria cornigera (*J. C. Fabr.*)	*80*	......	*80-100*	60	*25*
211. Cheirocratus Sundevalli (*Rath.*)	......	......	......	*25*	......
212. —— assimilis (*Lilljeb.*)	......	......	104	......	......
213. Gammarus locusta (*L.*)	......	......	......	*35*	......
214. Mæra Loveni (*Bruz.*)	*80*	......	......	*55-60*	......
215. —— longimana (*Leach*)	......	......	*90*	......	......
216. Amathilla homari (*Fabr.*)	......	65	......	......	......
217. Ampelisca macrocephala, *Lillj.*	*80*	......	......	......	......
218. —— tenuicornis, *Lillj.*	......	......	*80*	*35*	......
219. Haploops tubicola, *Lillj.*	......	......	......	*60*	......
220. —— setosa, *Boeck*	......	......	*100*	......	......
221. Podoceropsis Sophia, *Boeck*	......	......	......	......	......
222. —— undata, *Sp. Bate*	*25*	......	......	......	......
223. Cerapus abditus, *Templet.*	......	......	80	......	......
224. Evadne Nordmanni, *Lov.*	......	......	......	......	60-70
225. Calanus finmarchicus, *Gunner*	50-70	20-40	24-84	50	30-75
226. Euchæta norvegica, *Boeck*	......	......	......	......	64-75
227. Pseudocalanus elongatus, *Boeck*	70	20-40	24-84	50	35-75
228. Temora longicornis, *Müll.*	......	20-40	24-84	......	35
229. Centropages hamatus, *Lillj.*	70	20-40	24-84	50	35-70
230. Dias longiremis, *Lillj.*	70	40	20-80	50	30-70
231. Oithona spinifrons, *Boeck*	50-70	20-40	24-84	50	30-35
232. Ectinosoma atlanticum (*Br. & Rob.*).	......	......	24	......	......
233. Scalpellum vulgare, *Leach*	......	40	......	......	......
234. Balanus hameri (*Asc.*)	......	......	104 *d.*	......	......
83 species.					

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	42	......	......	......	Norway, U.S.A.
40	30–40	30–45	30	20	Norway.
......	......	......	......	20	Norway, Arctic, Medit.
40	......	......	......	......	Norway, Medit.
40	30–40	30–35	.....	......	Norway, U.S.A.
......	......	......	30	......	Norway, U.S.A.
40	40–45	......	30	......	Norway.
......	*43*	......	......	......	Norway.
......	......	......	......	......	Norway.
......	......	......	......	......	Medit.
......	......	......	......	......	Firth of Clyde to S. of Britain.
......	......	......	......	......	Firth of Clyde to S. of Britain.
......	......	......	......	......	Norway.
......	*39*	......	......	......	Norway.
......	......	......	......	......	Medit.
......	......	......	......	......	Norway, Medit.
......	......	......	......	......	Norway.
......	......	......	......	......	Norway.
......	......	......	......	......	Norway.
......	......	......	......	......	Norway to Medit.*
......	......	......	......	......	Norway.
......	......	......	......	......	Norway.
......	......	......	......	......	Moray Firth, Plymouth.
......	......	......	......	......	Plymouth.
......	*20*	......	......	......	S. Norway to S.W. France.
......	*39*	......	......	......	Norway, Arctic, Medit.
......	......	......	......	......	Norway to France.
......	......	......	......	......	Norway to France.
......	......	......	......	......	Norway, Labrador, Arctic, Medit.
......	......	......	......	......	Greenland, Spitzbergen to Denmark.
......	......	......	......	......	Norway.
......	......	......	......	......	Norway, Arctic.
......	......	......	......	......	Norway, Labrador.
......	......	......	......	......	Norway.
35	*20–25*	......	......	......	Norway, Arctic.
......	......	......	......	......	Norway, Arctic, U.S.A.
......	*39*	......	......	......	Norway.
......	......	......	......	......	Northumberland.
......	......	......	......	......	Medit., Atlantic.
......	......	......	......	......	North Sea, Medit.
35	20–42	35	40	20	Arctic, Norway, N. Atlantic, Southern Seas, Medit.
......	......	......	......	......	Scandinavia.
35	20–42	35	40	20	Scandinavia.
......	20–42	......	40	20	Norway.
......	20–42	......	40	......	North Sea, Medit.
35	20–42	35	40	20	Norway, North Sea, Medit.
35	20–42	......	50	20	Norway.
35	40	......	......	......	N. Atlantic.
......	......	......	......	......	European seas, Medit.
......	......	......	......	......	Iceland, Norway, Færoes, U.S.A.

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* Carus (Prodr. faun. Medit. p. 409) states that this is confined to the Mediterranean.

	Arran Basin.				
	Brodick Basin.	Kil-brennan Basin.	Inch-marnoch Basin.	Cumbrae Basin.	Upper Loch Fyne.
Vermes.					
235. Pontobdella muricata, *L.* ……	……	……	……	……	……
236. Aphrodite aculeata, *L.* ………	……	……	37–104	……	65-75
237. Hyalinœcia tubicola (*O. F. Müll.*)	……	……	……	……	……
238. Eumenia Jeffreysi, *M'I.* ………	80-90	40	104	……	65–75
239. Pectinaria belgica (*Pall.*) ……	80-90	……	37	……	……
240. Sabella pavonia (*Sav.*) ………	90	……	……	……	……
241. Filigrana implexa (*Berk.*) ……	80–90	22–70	37	……	50
242. Serpula vermicolaris (*L.*) ……	……	……	……	……	50
243. Leptoplana tremellaris ………	……	……	80		
9 species.					
Echinodermata.					
244. Cucumaria Hyndmanni (*Thomps.*)	……	*75–80*	……	……	……
245. Psolus phantapus (*Strussenf.*)…	……	……	*40*	……	……
246. Thyone fusus (*O. F. Müll.*)……	……	*75–80*	……	……	……
247. Holothuria intestinalis, *Asc. & Rath.*	……	50	……	……	……
248. Echinus esculentus, *L.*…………	……	……	37–80	……	30–80
249. —— miliaris, *P. L. S. Müll.* …	……	……	……	……	……
250. Brissopsis lyrifera (*Forbes*)……	50–90	22–40, *75–80*	37–104	50	……
251. Spatangus purpureus, *O.F.Müll.*	……	……	……	50	36
252. Echinocardium flavescens, *O. F. Müll.*	……	……	……	……	……
253. Porania pulvillus (*O. F. Müll.*)	……	22–45	37	……	……
254. Stichaster roseus (*O. F. Müll.*).	……	22	……	*20–30*	……
255. Crossaster papposus (*Linck*) …	……	22	……	……	……
256. Solaster endeca (*Gm.*) …………	……	……	……	……	……
257. Cribrella oculata (*Linck*) ……	……	……	80	……	……
258. Asterias rubens, *L.* ……………	……	22–40	40–80	……	……
259. —— violacea, *O. F. Müll.* ……	……	22	……	……	……
260. Ophioglypha affinis (*Ltk.*) ……	……	*75–80*	104	……	……
261. —— albida (*Forbes*)……………	……	……	……	……	50-75
262. —— lacertosa (*Penn.*)…………	……	……	80	……	50
263. Ophiopholis aculeata (*O.F.Müll.*)	……	……	37–104	……	50
264. Amphiura Chiajei, *Forbes* ……	50–90	22-40, *75–80*	*25*, 37–104	*20–60*	36–50
265. —— filiformis (*O. F. Müll.*) …	50–60	*75–80*	*100*	*35–60*	36
266. Ophiocoma nigra (*O. F. Müll.*).	……	……	……	……	……
267. Ophiothrix pentaphyllum (*Penn.*)	……	……	37	50	50–75
268. Antedon rosacea (*Linck*)………	……	……	……	……	……
25 species.					

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	40	......	......	......	North Sea, Medit.
......	40	35–40	30	20	Scandinavia to Medit., U.S.A.
......	......	35–40	......	......	Scandinavia to Medit., Madeira. [30–80 fms.
40	40	35–40	......	......	British seas.
......	40	......	......	......	Scandinavia to Britain.
......	......	35–40	......	......	Scandinavia, Britain. 20–100 fms.
......	......	......	......	......	Scandinavia to Medit. 20–300 fms.
......	......	35	......	......	Scandinavia to France. 15–80 fms.
......	......	......	......	......	Scandinavia to Medit.
......	......	......	......	......	Arctic, Scandinavia, U.S.A.
......	......	......	......	......	Scandinavia to Medit.
......	......	......	......	......	Arctic, Scandinavia.
40	30–40	30	30	20	Norway to English Channel.
......	......	45	......	......	Norway to English Channel.
......	30–42	......	......	......	Greenland and Norway to Medit., W. Indies, Florida, Cape of Good Hope. 0–2435 fms.
......	40	......	......	......	Norway to Medit., Azores, Bermuda, W. Indies. 0–45 fms.
30–40	*35*	......	......	......	Norway to France, Cape of Good Hope, Carolina to Florida. [0–150 fms.
......	......	......	......	......	Scandinavia. 15–106 fms.
......	......	......	......	......	Scandinavia. 2–50 fms.
......	30-40	......	......	......	Arctic and Norway to France, U.S.A. [0–640 fms.
......	30–40	......	......	......	Arctic and Norway to France, U.S.A. [0–150 fms.
......	......	......	......	......	Arctic to Britain, U.S.A. 0–1350 fms.
......	30–42	35	30	20	Only British. 0–53 fms.
......	30–40	45	......	......	Norway to Britain. 65 fms.
......	......	......	......	......	Scandinavia to Medit., U.S.A. [To 192 fms.
......	......	35	......	......	Scandinavia and Færoes to Azores, Medit. 5–458 fms.
......	......	......	30	20	Arctic North Atlantic, Medit., Madeira.
......	30–40	......	30	......	Arctic and Scandinavia. To 560 fms.
40	40	35	......	......	Scandinavia to Medit. To 555 fms.
......	*39*	......	......	......	Scandinavia to Medit. To 555 fms.
40	......	......	30	......	Arctic and Scandinavia. 7–87 fms.
40	30–40	......	30	......	France. 83 fms.
......	30–40	......	......	......	Hebrides to Madeira and Medit. [100 fms.

	Arran Basin.				Upper Loch Fyne.
	Brodick Basin.	Kilbrennan Basin.	Inchmarnoch Basin.	Cumbrae Basin.	
Cœlenterata.					
269. Hydractinia echinata (*Flem.*)	......	54	37–104	......	50
270. Perigonimus repens (*Wright*)	......	50	......	......	......
271. Dicoryne conferta (*Alder*)	......	......	......	......	......
272. Tubularia indivisa, *L.*	......	65	......	50	......
273. Campanularia angulata, *Hincks.*	......	50–64	......	......	......
274. —— volubilis (*L.*)	......	50–60	......	......	......
275. Lafoëa dumosa (*Flem.*)	......	49–64	......	......	......
276. —— fruticosa (*Sars*)	......	64	104	......	......
277. Calycella fastigiata (*Alder*)	......	49	......	......	......
278. Halecium Beauii, *Johnst.*	......	80	......	......	......
279. —— halecinum (*L.*)	......	......	104	......	......
280. —— muricatum (*Ell. & Sol.*)	......	49	......	......	......
281. Sertularella fusiformis, *Hincks*	......	......	104	......	......
282. —— Gayi (*Lamx.*)	......	30–50	......	......	......
283. —— rugosa (*L.*)	......	64	......	......	......
284. Diphasia attenuata, *Hincks*	......	30–64	......	......	......
285. —— fallax (*Johnst.*)	......	64	......	......	......
286. —— tamarisca (*L.*)	......	64	......	......	......
287. —— pinaster (*Ell. & Sol.*)	......	64	......	......	......
288. Sertularia abietina, *L.*	......	25	......	......	......
289. —— argentea, *Ell. & Sol.*	......	25–64	......	......	......
290. Hydrallmania falcata (*L.*)	......	25	......	......	......
291. Antennularia ramosa, *Lamk.*	......	64	......	......	......
292. Aglaophenia tubulifera, *Hincks.*	......	30–64	......	......	......
293. Plumularia Catharina, *Johnst.*	......	30–50	......	......	......
294. —— pinnata (*L.*)	......	49	......	......	......
295. Bolocera tuediæ (*Johnst.*)	......	......	37–104	......	70
296. Virgularia mirabilis (*O.F. Müll.*)	......	......	......	......	......
297. Pennatula phosphorea, *L.*	......	22–40	......	......	......
29 species.					
Porifera.					
298. Suberites ficus (*Johnst.*)	......	50	45–49	......	60–75
299. —— suberea (*Mont.*)?	......	20–45	......	......	70
300. Tragosia infundibuliformis (*Johnst.*)	......	50–70	80–104	......	......
301. Chalina, sp.	......	......	......	......	......
302. Myxilla incrustans (*Johnst.*)	......	50–65	......	......	......
303. Iophon Pattersoni (*Bwk.*)	......	64–65	80–100	......	......
304. Grantia ciliata, *Flem.*	......	......	......	......	......
7 species.					

Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gare-loch.	General Distribution.
......	40	......	30	......	France, U.S.A., Medit.?
......	......	......	......	......	Medit.
......	40	......	......	......	Shetland, Northumberland.
......	......	......	......	......	Greenland and Norway to Bay of Biscay, Medit.
......	......	......	......	......	N. Ireland to Channel Is.
......	......	......	......	......	Iceland, Norway, U.S.A., Medit. [20–100 fms.
......	......	......	......	......	Norway, U.S.A., Medit. Tide-marks [to 145 fms.
......	......	......	......	......	Iceland, Norway. 15–100 fms.
......	......	......	......	......	Shetland to Cornwall.
......	......	......	......	......	Medit.
......	......	......	......	......	Greenland and Norway to Medit., U.S.A. 30–50 fms.
......	......	......	......	......	Iceland, U.S.A. 30–50 fms.
......	......	......	......	......	Medit.
......	......	......	......	......	Normandy. 60 fms.
......	......	......	......	......	Greenland, Norway, and Labrador. [30 fms.
......	......	......	......	......	Port Adelaide, Medit.
......	......	......	......	......	Norway, U.S.A. 30 fms.
......	......	......	......	......	Bay of Biscay, U.S.A., Medit.
......	......	......	......	......	North Sea, Medit. 40–140 fms.
......	......	......	......	......	Greenland and Norway to Medit., U.S.A. 30 fms.
......	......	......	......	......	Greenland and Norway to Medit., U.S.A. 4–50 fms.
......	......	......	......	......	Belgium, U.S.A., S. Africa. 35 fms.
......	......	......	......	......	S. Africa.
......	......	......	......	......	Algoa Bay. 15–30 fms.
......	......	......	......	......	All British coasts. 40–60 fms.
......	......	......	......	......	North Sea, Medit.
......	......	35	......	......	Scandinavia, U.S.A.
40	......	40	......	......	Norway, Scotland.
......	......	......	......	......	European seas.
......	......	30–40	30	......	Hebrides, Northumberland, Mayo.
......	......	......	......	......	British coasts.
......	......	......	......	......	Shetland to Channel Is.
......	......	35			
......	......	......	......	......	British seas.
......	......	......	......	......	Shetland, Patagonia, Tristan da Cunha.
......	......	45	......	......	British coasts.

DISCUSSION OF THE RESULTS.

The above Table may be summarized in the more condensed one given below, in which the number of species of each group of animals from each basin is shown.

	ARRAN BASIN.					Upper Loch Fyne.	Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Gareloch.
	Brodick Basin.	Kilbrennan Basin.	Inchmarnoch Basin.	Cumbrae Basin.	Total.						
Pisces	10	29	12	7	36	6	6	20	3	5	7
Tunicata	1	...	6	...	6	5	...	2	3	1	
Mollusca	24	26	46	16	61	20	13	21	18	8	7
Brachiopoda	...	...	1	...	1	1					
Polyzoa	...	31	1	...	31						
Crustacea	24	29	46	34	75	20	16	31	14	16	15
Vermes	6	3	6	...	9	4	1	4	5	1	1
Echinodermata...	3	12	12	6	18	8	5	13	6	6	3
Cœlenterata	...	26	5	1	27	3	1	2	2	1	
Porifera	...	7	4	...	8	2	...	...	3	1	
Totals............	68	163	139	64	272	69	42	93	54	39	33

In dealing with these figures great caution must be observed, and it must always be borne in mind that no locality can ever be said to be really exhausted. The number of dredgings upon which the present inquiry is based will only suffice as a basis for very general conclusions. This has been abundantly evident during the progress of the work, for tables like the above have been drawn up several times, and it has been noticed that each successive addition of new data has increased the likeness of the faunas of the different basins to each other.

Certain sources of error must also be avoided; for instance, it was apparent, from an examination of the various lists, that the Polyzoa and Hydrozoa had only been exhaustively examined in the case of the Kilbrennan Basin. These groups must therefore be left out of account in comparing the different basins with each other. Furthermore, the Worms and Sponges have been very incompletely studied. Many specimens I was only able to refer to their generic position, and hence it seems advisable to omit these groups also from consideration for the present.

Deducting the figures corresponding to them, we have the following modified list of the total numbers of species from each basin:—

Brodick Basin	62
Kilbrennan Basin	96
Inchmarnoch Basin	123
Cumbrae Basin	63
Total from Arran Basin	197
Upper Loch Fyne	60
Loch Striven	40
Dunoon Basin	87
Loch Goil	44
Upper Loch Long	36
Gareloch	32

This revised series of totals proves beyond all doubt that the richest fauna is in those basins which are in closest proximity to the sea, and that it diminishes as we proceed into the more landlocked portions of the district. An exception, which is, however, more apparent than real, will be noticed in the fact that a larger number of species has been found in the Inchmarnoch Basin than in either the Brodick or Kilbrennan Basins. This is, I believe, to be explained partly by the fact that the Inchmarnoch Basin is much larger than either of the others, and descends to a greater depth, and partly by the circumstance that more dredgings have been carried out in it. If we take the Arran Basin as a whole the truth of the above proposition is obvious. It is, of course, just what might have been anticipated beforehand in view of the marine origin of the whole fauna, but it is satisfactory to have the matter established by actual investigation.

It will be of some interest to consider the relationships of this fauna as a whole, and particularly to ascertain which of the neighbouring faunas it most closely resembles.

For this purpose use must be made of the distributional notes appended to each species in the list. According to this information the species fall into three categories. The first contains those which range from Scandinavia to the Mediterranean, or even more widely still; these may be termed, for the present purpose, " Wide-spread " species. The second consists of those forms which are common to the Arctic and Scandinavian waters, and hence may be termed " Northern;'' whilst the third is made up of species which may be called " Southern," as they extend to the Mediterranean or the African coast.

The following Table shows the numbers of species of the various classes of animals which belong to each of these categories :—

	Wide-spread Species.	Northern Species.	Southern Species.
Pisces	23	17	2
Tunicata...............	4	5	
Mollusca and Brachiopoda ...	46	22	3
Polyzoa	20	5	1
Crustacea	32	41	5
Vermes	3	3	
Echinodermata	10	13	2
Cœlenterata	9	4	9
Totals	147	110	22

From these figures it appears that the major part of the fauna is composed of species which are dispersed more or less widely over the north temperate regions of the globe, whilst the smaller half is very unequally divided between the northern and southern species, the former being five times as numerous as the latter. In only one division of animals (the Cœlenterata) do the southern forms predominate over the northern, and this subkingdom has been hitherto very inadequately investigated in the Clyde area.

The depth of 20 fathoms as limiting what might be considered the deep-water fauna in the Clyde sea-area was selected not from any preconceived idea as to its significance, but because it was convenient for practical purposes, and because it was applicable to all the lochs, the extreme depth of the Gareloch, which is the shallowest, being about 23 fathoms. In the case of some of the other basins, however, it is so far from marking out their limits that it does not touch the tops of the ridges which separate them. To Dr. Murray I owe the suggestion that it might be worth while to compare the faunas of the deepest parts of the basins, taking some other contour-line as the upper limit. I have therefore gone over the Table given above and selected from it those species which are found in proximity to the bottom of each basin. The depressions themselves vary so much in depth that I have thought it advisable to record both the forms which are found below the 50-fathom line and (in a separate column) those which are found within, say, 5 to 20 fathoms of the bottom of each basin. Furthermore I have excluded those free-swimming forms whose distribution in regard to depth cannot be regarded as absolutely fixed. On this ground I have omitted the Fishes, Cephalopoda, Amphipoda, and part of the Macrurous Crustacea (viz. the genera *Hippolyte*, *Pandalus*, and their allies); the Polyzoa, Hydroida, and Sponges have also been neglected because they have been insufficiently studied.

In the subjoined Table the following symbols have been used:—

*=occurring at the depth mentioned in the head of the column.

†=occurring in the locality, but at a depth less than those under consideration in the table.

W=Widely-spread species.
N = Northern species.
S = Southern species.

	Arran Basin.							Upper Loch Fyne.		Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Distribution.
	Brodick Basin.		Kilbrennan Basin.		Inchmarnoch Basin.		Cumbrae Basin.							
	50 to 92.	75 to 92.	50 to 85.	70 to 85.	50 to 104.	80 to 104.	50 to 62.	50 to 77.	65 to 77.	35 to 41.	40 to 55.	35 to 40.	30 to 34.	
Tunicata.														
1. Cynthia echinata, *L.*	...	...	...	...	*	*	...	...	...	...	...	...	...	N.
2. Styela grossularia, *v. Ben.*	*	...	...	...	*	*	...	*	*	...	...	...	*	N.
3. —— rustica, *L.*	...	...	...	...	*	*	...	*	*	...	...	...	...	N.
4. Polycarpa pomaria, *Sav.*	...	...	...	...	...	...	...	...	...	...	*	*	...	W.
5. Corella parallelogramma, *Müll.*	...	..	...	...	...	...	...	*	...	...	...	*	...	N.
6. Ciona intestinalis, *L.*	...	...	...	..	...	...	...	*	...	...	...	...	...	W.
7. Ascidia mentula, *Müll.*	...	...	...	...	†	...	...	*	*	...	*	*	...	N,
8. —— scabra, *Müll.*	...	...	...	...	*	*	...	...	...	...	...	...	...	W.
9. —— virginea, *Müll.*	...	...	...	...	*	*	...	...	...	...	...	...	...	W.
Mollusca.														
10. Pleurotoma (Bela) turricula (*Mont.*)	...	...	...	...	†	...	*	...	...	*	*	...	...	N.
11. Chrysodomus antiquus (*L.*)	*	*	*	...	*	*	*	*	...	...	*	*	*	N.
12. Fusus (Sipho) gracilis (*Da C.*)	†	...	†	...	*	*	*	*	...	*	*	*	*	N.
13. Buccinum undatum, *L.*	...	...	*	...	*	*	...	*	*	*	*	*	*	N.
14. Aporrhais pes-pelecani (*L.*)	...	...	†	...	†	...	*	...	...	*	*	...	...	W.
15. Turritella terebra (*L.*)	*	*	†	...	†	...	*	...	...	...	*	...	...	N.
16. Rissoa abyssicola, *Forbes*	...	...	...	...	*	*	...	...	...	...	...	...	...	W.
17. Velutina lævigata (*Penn.*)	...	...	...	...	*	*	...	*	..	...	...	*	...	N.
18. Natica Alderi, *Forbes*	...	...	...	...	*	*	...	...	...	...	...	...	...	W.

19. —— Montagui, *Forbes*	*	...	...	...	*	*	*	...	...	..	*	...	...	N.
20. —— sordida, *Phil.*	*	*	†	...	...	*d.*	*	...	...	...	...	*	...	W.
21. Trochus (Gibbula) cinerarius, *L.*	...	...	...	...	†	*d.*	*	*	*	*	*	*	*	W.
22. —— (Zizyphinus) zizyphinus, *L.*	...	...	*	...	...	...	...	...	...	...	...	...	...	W.
23. —— (——) millegranus, *Phil.*	...	...	†	...	*	*	...	†	...	...	*	...	...	W.
24. Puncturella Noachina (*L.*)	...	...	...	...	*	*	...	*	...	...	...	...	...	W.
25. Chiton marginatus, *Penn.*	...	...	...	...	*	*	...	*	...	...	...	...	...	N.
26. Dentalium entalis, *L.*	*	*	...	...	*	*	...	*	*	...	...	*	...	W.
27. Anomia ephippium, *L.*	*	...	...	...	†	...	...	...	...	...	*	...	...	W.
28. —— patelliformis, *L.*	...	...	†	...	...	...	...	*	*	...	...	...	...	W.
29. Lima elliptica, *Jeffr.*	*	*	...	...	*	*	...	...	...	...	...	*	...	W.
30. Pecten opercularis (*L.*)	†	...	*	...	†	...	*	*	*	*	*	...	...	W.
31. —— pusio (*L.*)	*	...	*	...	...	...	...	*	*	...	...	...	...	W.
32. —— septemradiatus, *Müll.*	*	*	*	*	*	*	*	*	*	*	*	*	...	W.
33. —— striatus, *Müll.*	*	*	...	...	†	...	*	...	...	...	...	...	...	N.
34. Modiola barbata (*L.*)	...	...	...	...	...	...	...	*	*	...	...	...	...	S.
35. Nucula nitida, *Sow.*	*	...	...	...	*	*	*	...	...	*	*	*	*	W.
36. —— nucleus (*L.*)	*	...	...	...	...	...	...	...	...	...	...	...	...	W.
37. —— sulcata, *Bronn*	*	*	*	*	*	*	*	...	...	*	*	*	...	W.
38. —— tenuis (*Mont.*)	...	...	...	...	*	*	...	...	...	...	*	...	...	N.
39. Leda minuta (*Müll.*)	...	...	†	...	*	*	...	...	...	...	...	*	...	N.
40. Astarte elliptica, *Brown*	*	...	...	...	†	...	...	...	...	...	...	...	...	N.
41. —— sulcata (*Da C.*)	*	...	*	*	*	*	...	*	...	...	...	...	...	W.
42. Cardium fasciatum, *Mont.*	...	...	...	...	...	...	*	...	...	...	...	...	...	W.
43. —— minimum, *Phil.*	...	...	...	...	*	*	...	...	...	...	...	...	...	N.
44. Cyprina islandica (*L.*)	...	...	*	...	†	...	..	...	...	...	...	...	...	N.
45. Isocardia cor (*L.*)	*	...	...	...	...	...	...	...	...	...	...	...	...	W.
46. Venus ovata, *Penn.*	*	...	...	...	†	...	...	...	...	...	...	...	...	W.
47. Cryptodon ferruginosus (*Forbes*)	*	...	...	...	...	...	...	...	...	...	...	†	...	W.
48. —— flexuosus (*Mont.*)	...	...	...	...	...	...	...	...	...	...	...	*	...	W.
49. —— croulinensis (*Jeffr.*)	*	...	...	...	..	...	...	...	...	...	...	...	...	W.
50. Mactra elliptica, *Brown*	...	...	...	...	*	*	...	...	...	...	...	...	...	N.
51. Corbula gibba, *Olivi*	*	...	†	...	...	...	*	†	...	*	*	*	*	W.
52. Saxicava rugosa (*L.*)	*	...	...	...	...	...	...	...	...	...	...	...	...	N.

	ARRAN BASIN.							Upper Loch Fyne.		Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Distribution.
	Brodick Basin.		Kilbrennan Basin.		Inchmarnoch Basin.		Cumbrae Basin.							
	50 to 92.	75 to 92.	50 to 85.	70 to 85.	50 to 104.	80 to 104.	50 to 62.	50 to 77.	65 to 77.	35 to 41.	40 to 55.	35 to 40.	30 to 34.	
53. Semele (Abra) alba (*Wood*)	*	*	...	...	*	*	*	*	...	*	*	*	*	W.
54. —— nitida, *Müll.*	...	...	...	...	*	*	...	...	...	...	...	...	...	W.
55. —— tenuis (*Mont.*)	...	...	...	...	...	...	...	...	...	...	...	*	...	S.
56. Cuspidaria abbreviata, *Forbes*...	...	...	...	...	...	...	...	...	...	*	...	...	...	W.
BRACHIOPODA.														
57. Terebratulina caput-serpentis (*L.*)	...	...	...	...	*	*	...	*	...	...	...	...	...	W.
CRUSTACEA.														
58. Inachus dorsettensis, *Penn.* ...	...	...	...	...	*	*	*	*	...	...	*	...	...	W.
59. Hyas araneus, *L.*	...	...	...	...	...	...	...	*	...	...	*	...	...	N.
60. —— coarctatus, *Leach*	*	...	*	...	†	...	*	*	*	...	*	...	*	N.
61. Stenorhynchus longirostris, *M.-Edw.*	...	...	†	...	†	...	*	...	...	...	...	...	...	W.
62. —— rostratus, *L.*	...	...	*	...	...	...	...	...	...	...	...	...	...	N.
63. Eurynome aspera, *Penn.*	...	...	...	...	...	...	*	...	...	...	...	...	...	W.
64. Portunus depurator, *L.*	*	*	?	...	*	*	*	...	...	...	*	†	*	W.
65. —— pusillus, *Leach*	...	...	...	...	*	*	...	...	...	...	...	...	...	W.
66. Ebalia tuberosa, *Penn.*	...	...	...	...	...	...	*	...	...	...	...	...	...	W.
67. Lithodes maia (*L.*).	...	...	?	...	†	...	...	*	*	...	...	*	*	N.
68. Eupagurus bernhardus (*L.*). ...	...	...	*	*	*	*	*	*	*	*	*	*	*	W.

69. —— Prideauxii (*Leach*)..........	...	...	*	...	...	...	*	...	...	...	*	...	...	W.
70. —— pubescens (*Kröyer*).........	...	...	*	...	...	...	*	...	...	...	...	...	...	N.
71. Anapagurus lævis (*Thompson*).	...	...	?	...	*	*	*	...	...	...	...	...	...	W.
72. Galathea dispersa, *Sp. B.*	*	*	...	...	...	...	...	...	...	...	...	...	...	N.
73. —— nexa, *Embleton*	*	*	...	...	...	...	...	...	...	...	*	...	...	W.
74. —— squamifera, *Leach*	...	...	†	...	...	...	...	*	*	...	...	...	...	W.
75. Munida rugosa (*Fabr.*).	*	*	...	...	...	...	...	...	...	*	*	*	...	W.
76. Calocaris Macandreæ, *Bell*......	*	*	...	...	*	*	*	...	...	...	*	...	...	W.
77. Nephrops norvegicus (*L.*).	*	*	†	...	†	...	...	...	...	*	*	*	...	W.
78. Crangon Allmani, *Kinahan* ...	*	*	*	*	*	*	*	*	*	*	*	*	*	N.
79. —— echinulatus, *M. Sars*	...	...	...	...	*	*	...	...	...	...	...	...	...	N.
80. Nika edulis, *Risso*	*	*	...	...	*	*	...	...	...	...	...	...	...	W.
81. Nyctiphanes norvegica (*M. Sars*)	*	*	...	...	*	*	...	*	*	*	*	*	...	N.
82. Boreophausia Raschi (*M. Sars*).	...	...	...	...	...	...	*	...	...	*	*	...	*	N.
83. Cirolana hirtipes, *M.-Edw.*......	...	...	...	...	*	*	†	...	...	...	...	...	...	S.
84. Conilera cylindracea (*Mont.*) ...	...	...	...	...	...	...	*	...	...	...	...	...	...	
85. Janira maculosa, *Leach*	...	...	...	...	*	...	...	...	...	...	...	...	...	N.
86. Arcturus longicornis (*Sowb.*) ...	...	...	†	...	*	*	†	...	...	...	†	...	...	N.
87. Idotea paralléla, *Sp. B. & W.*	...	...	...	...	...	...	*	...	...	...	...	...	...	S.
VERMES.														
88. Aphrodite aculeata, *L.*	...	...	...	...	*	*	...	*	*	...	*	*	*	W.
89. Hyalinœcia tubicola (*O. F. Müll.*)	...	...	...	...	...	...	...	...	...	...	...	*	...	W.
90. Eumenia Jeffreysi, *M'I.*	*	*	†	...	*	*	...	*	*	*	*	*	...	
91. Pectinaria belgica (*Pall.*)	*	*	...	...	†	...	...	...	...	...	*	...	...	N.
92. Sabella pavonia (*Sav.*)............	*	*	...	...	...	...	...	...	...	...	...	*	...	N.
93. Filigrana implexa (*Berk.*)	*	*	*	*	†	...	...	*	...	...	...	...	...	W.
94. Serpula vermicolaris (*L.*)	...	...	...	...	...	...	...	*	...	...	...	...	...	N.
95. Leptoplana tremellaris(*O. F. M.*)	...	...	...	...	*	*	...	...	...	...	...	...	...	W.

	Arran Basin.							Upper Loch Fyne.		Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.	Distribution.
	Brodick Basin.		Kilbrennan Basin.		Inchmarnoch Basin.		Cumbrae Basin.							
	50 to 92.	75 to 92.	50 to 85.	70 to 85.	50 to 104.	80 to 104.	50 to 62.	50 to 77.	65 to 77.	35 to 41.	40 to 55.	35 to 40.	30 to 34.	
ECHINODERMATA.														
96. Cucumaria Hyndmanni (*Thomps.*)	...	...	*	*	...	...	...	...	...	...	...	...	...	W.
97. Thyone fusus (*O. F. Müll.*)	...	...	*	*	...	...	...	...	...	...	...	...	...	W.
98. Holothuria intestinalis (*Asc. & Rath.*)	...	...	*	...	...	...	...	...	...	...	...	...	...	N.
99. Echinus esculentus, *L.*	...	...	...	...	*	*	...	*	*	*	*	†	*	N.
100. Brissopsis lyrifera (*Forbes*)	*	*	*	*	*	*	*	...	...	*	..	...	...	W.
101. Spatangus purpureus, *O. F. Müll.*	...	...	...	...	...	...	*	†	...	...	*	...	...	W.
102. Echinocardium flavescens (*O. F. Müll.*)	...	...	...	...	...	...	...	...	...	*	†	...	...	W.
103. Cribrella oculata (*Linck*).	...	...	...	...	*	*	...	...	...	...	...	...	...	N.
104. Asterias rubens, *L.*	...	...	†	...	*	*	...	...	...	...	*	*	*	N.
105. —— violacea, *O. F. Müll.*	...	...	†	...	...	...	...	...	...	...	*	*	...	N.
106. Ophioglypha affinis (*Ltk.*)	...	...	*	*	*	*	...	...	...	...	...	...	...	W.
107. —— albida (*Forbes*).	...	...	...	...	...	...	...	*	*	...	...	...	...	W.
108. —— lacertosa (*Penn.*)	...	...	...	...	*	*	...	*	...	...	...	...	*	W.
109. Ophiopholis aculeata (*O. F. Müll.*)	...	...	...	...	*	*	...	*	...	...	*	...	*	N.
110. Amphiura Chiajei, *Forbes*	*	*	*	*	*	*	*	*	...	*	*	*	...	W.
111. —— filiformis (*O. F. Müll.*)	*	...	*	*	*	*	*	†	...	...	†	...	...	W.
112. Ophiocoma nigra (*O. F. Müll.*)	...	...	...	...	...	...	...	...	...	*	...	...	*	N.
113. Ophiothrix pentaphyllum (*Penn.*)	...	...	...	...	†	...	*	*	*	*	*	...	*	S.

If the preceding table be summed up in the same manner as the first one the result is found to be as follows:—

	ARRAN BASIN.							Upper Loch Fyne.		Loch Striven.	Dunoon Basin.	Loch Goil.	Upper Loch Long.
	Brodick Basin.		Kilbrennan Basin.		Inchmarnoch Basin.		Cumbrae Basin.						
	50 to 92.	75 to 92.	50 to 85.	70 to 85.	50 to 104.	80 to 104.	50 to 62.	50 to 77.	65 to 77.	35 to 41.	40 to 55.	35 to 40.	30 to 34.
Tunicata	1	...	...	...	5	5	......	5	3	...	2	3	1
Mollusca	22	9	9	3	23	21	16	15	8	12	17	16	7
Brachiopoda	...	...	...	...	1	1	......	1					
Crustacea	10	9	9	2	13	12	15	8	6	7	13	6	6
Vermes	4	4	1	1	3	3	......	4	2	1	3	4	1
Echinodermata	3	2	7	6	9	9	5	6	3	6	7	3	6
Totals	40	24	26	12	54	51	36	39	22	26	42	32	21

It is obvious at once that these numbers do not show so clearly as those previously obtained the gradual diminution in the number of species in the different basins. There is a slight tendency in this direction, but the exceptions are rather numerous, and if we take the bottom faunas of each basin instead of that below 50 fathoms the series of numbers is:—

24, 12, 51, 36, 22, 26, 42, 32, 21.

This result is extremely interesting because it seems to show that the bottoms of the remoter basins have a fauna which approaches the more seaward basins in respect of variety more nearly than do their faunas taken as a whole. It suggests the possibility that we have in these basins, in addition to the fauna derived from the present outer seas, which seems to be gradually making its way into them, a fauna which has been in them for a much longer period.

Regarding the range of distribution of the species which are confined to these depressions we find:—

	Wide-spread Species.	Northern Species.	Southern Species.
Tunicata	4	5	
Mollusca	30	15	2
Brachiopoda	1		
Crustacea	15	12	2
Vermes	3	3	
Echinodermata......	10	6	1
Totals	63	41	5

Here, curiously enough, the wide-spread forms preponderate over the others more than was the case in the previous list; but it is noteworthy that the percentage of southern forms has diminished, which emphasizes still more strongly the Arctic and Scandinavian affinities of the Clyde deep-water fauna. These results illustrate in a very interesting manner several of the generalizations of the late Edward Forbes.

In conclusion, I may be allowed to express the hope that the facts recorded above may furnish the nucleus of more extended series of observations. I hope to continue the work as opportunities arise, and I shall be extremely grateful to any naturalists who will furnish me with records of the occurrence, with the exact locality and depth, of any species in the Clyde sea-area or neighbouring seas.

NOTES ON THE ZOOLOGY OF FERNANDO NORONHA.

By H. N. RIDLEY, M.A., F.L.S.

[Read 7th June, 1888.]

(PLATE XXX.)

INTRODUCTION.

ON July 9th, 1887, the writer, with Mr. G. A. Ramage, of Edinburgh, started for Brazil to thoroughly explore the island of Fernando Noronha, lying in long. 32° 25′ 30″ W. and lat. 3° 50′ 10″ S., at a distance of 194 miles N.E. from Cape San Roque, coast of Brazil. On arriving at Pernambuco we were joined by the Rev. T. S. Lea, who came as a volunteer at his own expense. The cost of the expedition was defrayed by the Royal Society. After some delay at Pernambuco we embarked in the 'Nasmyth' steamship, trading to Liverpool, which was permitted to land us at the island, as the regular steamer trading between Pernambuco and Fernando Noronha was detained for a long time just as she was due to start. We arrived at our destination on August 14th, and remained there till September 24th, when we returned by the little Brazilian steamer to the mainland. We occupied ourselves in exploring, and in collecting plants, animals, and rock-specimens in all parts of the main islands, and visited also most of the other islets which were accessible; but owing to the absence of boats, which, on account of the convict-station, are not permitted on the island, we were unable to obtain much by dredging. The coral-reefs, however, at low tide afforded an abundant harvest of marine animals and plants.

Having in the 'Introduction' to my "Notes on the Botany of Fernando Noronha," printed in the 'Journal of the Linnean Society' (Botany, vol. xxvii. p. 1), given a detailed account of the group of islands of which this is the chief, as well as a history of its discovery by Amerigo Vespucci in 1503, it will be unnecessary to repeat what has there been stated. For the better understanding, however, of the special reports on Zoology which are now furnished, the following extracts from the Introduction referred to may be found useful.

Vespucci's description of the trees and innumerable birds is evidently correct, though most of the trees are destroyed, and the birds far less abundant than they were then. The lizards with two tails may have been a confusion of the very abundant and conspicuous Gecko with the *Amphisbæna*, which is often called the snake with two heads, or may have been suggested by finding an accidentally fork-tailed lizard, of which an example was obtained by our expedition. The "serpents" were doubtless the *Amphisbæna*. The large rats are much less easy to explain; at present the only rats occurring on the island are *Mus rattus*, the common introduced black rat. It is impossible that the animals seen by Vespucci could have been this species, which could not at that time have been introduced. It is possible that there was formerly an indigenous rat-like mammal, which became exterminated by the black rat. We could find no tradition even of this big rat, and I fear it is quite extinct. The only hope of recovering its remains lies in an examination of the guano deposits of Rat Island, where its bones might be preserved.

The number of insects belonging to the orders which are well known as plant-fertilizers is surprisingly limited. A few small species of moths haunted at night the bushes of *Scoparia dulcis*, *Cassias*, &c. on the open spaces. A single species of butterfly was very abundant on Rat Island and the main island, but we never saw it visiting flowers.

The most important fertilizer was a small endemic hornet belonging to the genus *Polistes*, which gathered honey from the Leguminosæ and Cucurbitaceæ; and three small black species of *Halictus* were caught in the flowers of the melons, *Momordica charantia*, *Oxalis Noronhæ*, and the mustard. The last plant was also haunted by *Temnoceras vesiculosus*, a pollen-eating Syrphid. The only other insects which could also be considered as possible fertilizers were *Tachytes inconspicuus*, n. sp., and *Monedula signata*, two sand-wasps, *Pompilus nesophila*, n. sp. (Hymenoptera), and *Psilopus metallifer* (a Dipteron), but none of these were seen at or near flowers. A small black beetle also was found in the flowers of an *Acacia* in the Governor's garden.

Though the number of species of insects was not large, the individuals, especially of the *Polistes* and *Halicti*, were very numerous, but at the same time they seemed out of all proportion to the immense number of flowers to be fertilized. It is very probable, however, that the majority of the Leguminosæ and some of the other plants were self-fertilized.

The lake on the main island contained a species of *Nitella* and an alga, an aquatic beetle and an Hemipteron, a new species of

Planorbis, and an Ostracod, the latter also occurring in all the streams of any size. The remaining streams and puddles produced dragonflies, a species of *Gammarus*, and a few algæ. One may compare this state of things with the freshwater fauna and flora of the other Atlantic islands. The absence of freshwater fish and amphibians is common to most small islands.

Just as with plants, a considerable number of animals have been introduced by man into the islands intentionally and by accident: such, for instance, as the Gecko (*Hemidactylus mabouia*), the American Cockroach (*Blatta americana*), and its curious parasite *Evania*, a spider, centipede, scorpion, rats and mice, and *Sitoplidus oryzæ*. These, though usually plentiful on the main island around the houses, are markedly absent from the smaller islets.

There are also many visitors which have arrived here by the aid of their wings, probably assisted by a suitable wind. They include a number of the peculiar terrestrial fauna, the land-birds and the insects. On looking over the lists of species taken here, we may note that the smaller birds are endemic, and a large proportion of the smaller insects. The small butterfly and almost all the moths are known from the mainland of South America, and the dragonflies are also widely distributed forms. All the winged fauna have a South-American facies, whether they are endemic or of wider distribution.

There are other creatures unprovided with means of traversing the ocean and not introduced by man. They include the *Amphisbæna*, Skink, the freshwater and terrestrial Mollusca, and perhaps some of the feebler-winged and apterous insects, the endemic ostracod, &c.

The *Planorbis*, *Gammarus*, and Ostracod, all supposed to be endemic species, may possibly have been brought over on the feet of Wading birds, which migrate here.

The presence of some others is more difficult to account for. The Mollusca are almost all peculiar, and the two that are not so are West-Indian. The *Amphisbæna* and Skink are endemic, and allied not to Brazilian but to West-Indian forms.

It is commonly said that reptiles and terrestrial mollusks find their way across the ocean by secreting themselves, or their eggs, on floating trees, which are drifted to islands; and though for several reasons this does not seem a satisfactory explanation of their distribution, yet the appearance of these animals here suggests this as the means by which they may have arrived. As

I have said, they are West-Indian in their affinities, and it is a striking fact that the marine fauna and flora are mainly West-Indian, while at least one of the plants (*Ipomœa Tuba*) whose seeds are known to be constantly drifted about at sea, and thus carried from place to place, is also only known from the West Indies. Another fact of interest in connection with this sea-travelling fauna, if I may use the expression, is that almost all the species noted occur on all the islands suitable for their existence. Thus, on Rat Island the ***Bulimus Ridleyi***, the ***Amphisbæna***, and Skink are common on St. Michael's Mount; the Skink is a large species, but the island, being a mere rocky peak, is unsuited for the ***Amphisbæna***.

On Platform Island the lizard and several terrestrial Mollusca were found, while at the same time almost all the animals of more recent introduction were absent from these localities, just as is the case in the distribution of the plants. I believe, in fact, that this part of the fauna and flora was established on the island before it was broken up into the little archipelago of rocks and islets of which Fernando Noronha now consists*. Perhaps even this portion of the fauna and flora was introduced previously to the deposition of the basalt over the masses of phonolite which form as it were the skeleton outline of the island.

MAMMALIA.

No indigenous Mammals are to be found on these islands, and notwithstanding their proximity to the mainland, where Bats are abundant, no Bat of any species was observed by us, nor had the convicts ever seen any. Rats and Mice are exceedingly common. The Rat (***Mus rattus***) is here much paler than usual, and generally of a grey colour, while albinos are sometimes met with. It frequents the melon-fields and the tops of the cocoanut-trees, and is very destructive. The common House-Mouse, ***M. musculus***, is even more abundant, and has suggested the name Rat Island (Ilha do Ratta), where it is as common as on the mainland. It swarms everywhere, and is so tame that it is often caught by the hand. I have seen one in the evening on the top of the inflorescence of a *Crotalaria*, apparently devouring the young seed-pods. Albinos are often seen. There being no birds or beasts of prey to keep these animals in check, and food being particularly abundant, they have increased enormously, and one of the employments of a convict is to capture a certain number of rats and mice once a month. At the monthly rat-hunt while we were on the island over 3900 were taken; but we were assured that, in the dry season, when the herbage which covered the greater part of the island was dried up and burnt, the mice were compelled to leave their holes, and many more were taken. The hunts are then undertaken weekly, and 20,000 have been caught in a day. The bodies are piled up in the square after evening service, and the numbers counted.

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* On reference to A. Vespucci's description of the place, it will be found that he speaks of it as one island, so the breaking-up into an archipelago can only have taken place within the last 400 years.

The Cat is said to have become feral on the main island; and on Rat Island and one or two of the other islands we saw a large black Cat which had escaped from an Italian vessel wrecked there, and which had run wild.

In Amerigo Vespucci's account of the island above quoted, he mentions "*Mures quam maximi.*" What these were we cannot now determine, but it is highly improbable that they were *Mus rattus.*

A species of Dolphin was constantly seen in San Antonio Bay and also off Rat Island. One was captured during our visit; its stomach contained many cuttlefish and prawns, the latter very similar to the common edible prawn of Pernambuco. Whales also passed within sight of the island on one occasion, but we did not see them.

AVES.

By R. Bowdler Sharpe, F.L.S., &c.,
Assistant in the Zoological Department, British Museum.

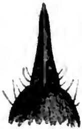
The birds of the island are not very numerous as regards species, and apparently there are only three indigenous Land-birds. The species of Sea-birds found by Mr. Ridley are precisely what one might have looked for, but it is a little remarkable that no Petrel was observed.

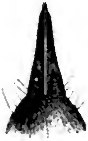
Fam. Vireonidæ.

1. **Vireo gracilirostris**, sp. n.

V. similis *V. magistro,* et forsan proximus, sed forma graciliore, coloribus dilutioribus, facie laterali pallide flavicante, et rostro valde tenuiore et graciliore distinguendus. Long. tot. 5·7, culmin. 0·6, alæ 2·5, caudæ 2·25, tarsi 0·8.

Five specimens were procured, and after comparing them with the series of *Vireonidæ* in the British Museum, there is no doubt that the Fernando Noronha bird comes nearest to *V. magister*, of which species the Museum has now a large series from the islands of the Bay of Honduras, presented by Messrs. Salvin and Godman. The yellow face and the slender bill distinguish it at a glance from *V. magister*.


Bill of *V. gracilirostris.*


Bill of *V. magister.*

Fam. Tyrannidæ.

2. **Elainea Ridleyana.**

Elainea Ridleyana, *Sharpe, P. Z. S.* 1888, p. 107.

This species has been fully described by me (*l. c.*). Dr. Sclater (Cat. B. Brit. Mus. xiv. p. 139) does not consider it to be very different from *E. pagana,* but the size of the bill is very marked in the insular birds.

[This bird occurred only on the main island and Rat Island as far as we saw, and was very common in the gardens and in the woods. We saw only a few nests, and of these only one was finished and contained an egg, which was destroyed in an attempt to reach the nest. The egg was white with dark red spots. The nest, which was about three inches across, was made of the tendrils of Cucurbitaceæ and a few fine twigs, but lined thickly (and in fact almost entirely constructed in some cases) with the woolly down of the seeds of *Gonolobus micranthus.* It was placed often in the bare branches of a Burra or *Erythrina* tree, or in a Cashewnut-tree.—*H. N. R.*]

Fam. COLUMBIDÆ.

3. ZENAIDA MACULATA.

Zenaida maculata (*V.*), *Scl. & Salv. Nomencl. Av. Neotr.* p. 132 (1873).
Zenaida aurita, *Gray, List Gallinæ etc. Brit. Mus.* p. 14 (1855).
Zenaida noronha, *Gray, List Columbæ*, p. 47 (1856, descr. nullâ).

The bird from Fernando Noronha is merely a small race of the ordinary *Z. maculata* of the South-American continent, with a slightly shorter wing (5·1–5·4 inches) and tail (2·75–3·2); but as some Brazilian specimens are of the same dimensions, I do not see how the idea of a small insular race can be maintained.

[This little Dove is exceedingly common on all the islands where it can find food, and flies about from one island to the other, singly or in flocks of from 2 or 3 to 30. It is very tame, and even when fired at, or alarmed, usually goes but a short distance before settling. The nest is loose in texture, about 6 inches across, and built of small sticks of the *Spermacoce*, vetches, &c., and lined with roots. It is placed often in the bare branches of a Spondias or Burra, with no attempt at concealment. The eggs are two in number, white, blunt at both ends, and about 1¼ inch long. One bird shot off its nest proved to be a male. The convicts catch these birds both for eating and as pets, keeping them in wicker cages. They are fed on the seeds of Cassias and other Leguminosæ and Cucurbitaceæ, and probably the fig and other succulent fruits.—*H. N. R.*]

Fam. LARIDÆ.

4. ANOUS MELANOGENYS, *Gray*; *Sharpe, Phil. Trans.* vol. 168. p. 467 (1879).

Two adults and a young bird agreed perfectly with specimens obtained on St. Paul's Rock by the 'Challenger' Expedition and determined by Mr. Howard Saunders. The young bird is browner than the adult, and has the head sooty brown with some white on the forehead, eyebrows, and occipital region.

[This Noddy was very common on the island, and is called "Viuva preta." A specimen also flew on board the vessel as we were going to Pernambuco from Europe, about a day's steam from Fernando Noronha. The species nests in small colonies on the rocks in various spots, and also in trees in the Sapate. An egg was obtained from a nest on St. Michael's Mount; it was oval and blunt at both ends, 2⅛ inches long, and about 1 inch through in the thickest part, chalky-white in colour, marked somewhat sparingly with underlying ash-grey, and overlying sienna. A living young bird from the nest was brought to me, but soon died.—*H. N. R.*]

5. Gygis candida (*Gm.*); *Sharpe, t. c.* p. 465.

One adult and two young birds. The latter are white like the old birds, but have much smaller bills.

[This is a common bird in many parts of the island, nesting in trees, especially those of the Sapate, where there is a colony near that of the *Anous*. The bird is called "Viuva bianca."—*H. N. R.*]

Fam. Pelecanidæ.

6. Phaethon æthereus (*L.*); *Scl. & Salv. Nomencl. Av.* p. 124.

Of this Tropic-bird two specimens were procured. It is common on the island, nesting on the Peak and on other rocks and cliffs. An egg was obtained on St. Michael's Mount. The birds were taken in snares by the convicts.

7. Sula leucogastra.

An adult and a young bird. This species of Gannet, known as "Mbebu," is a common bird, nesting on cliffs on all the islands. The young are pure white.

Besides these birds we saw several of which no specimens were procured. *Tachypetes aquila* was abundant, nesting on St. Michael's Mount, and a small species of Albatros appeared several times round the island, but kept well out of gun-shot. Three species of Waders were seen:—One, a small Plover, of which we twice saw a flock at San Antonio Bay, and once or twice single birds flying along the coral-reefs; a bird resembling a Yellowshank, grey and white, of which a pair appeared at San Antonio at the end of our visit; and a single specimen of a Sandpiper, at the same spot and time. These wading birds were all very shy, in marked contrast to the endemic species, which suggested that they were migrants, and had come from the mainland, where they are more cautious at the sight of man. The last two species appeared on the same day towards the end of our visit, which confirmed the view that they were migrating.

REPTILIA.

By G. A. Boulenger, F.Z.S.,
Assistant in the Zoological Department, British Museum.

Only three species were found, viz. a Gecko (*Hemidactylus mabouia*, Mor.), a Skink (*Mabuia punctata*, Gray), and an *Amphisbæna*, described below.

The Gecko is of a widely-distributed species, ranging over the greater part of Tropical America and Africa.

The Skink was originally described from two specimens obtained on Fernando Noronha by H.M.S. 'Chanticleer,' but has since been recorded from Demerara. The specimens brought home by Mr. Ridley are 10 in number; two have 36 scales round the body, the others 38; in one specimen the frontonasal touches the rostral and in another the two shields form a narrow suture.

Amphisbæna Ridleyi, sp. n.

Under this name I propose to designate an *Amphisbæna* of which a specimen, stated to be from Porto Bello, West Indies [*], presented by Capt. Austin, R.N., has been in the British Museum for nearly 50 years, and was referred by Gray, Strauch, and myself to *A. cæca*, D. & B. The same species has been found by Mr. Ridley on Fernando Noronha, and on re-examining the question I find that *A. cæca*, which occurs on various West-Indian Islands, but which was unrepresented in the British Museum when I published my Catalogue, must be regarded as distinct from the one with which I have now the pleasure of connecting Mr. Ridley's name.

16 specimens were collected by Mr. Ridley. One has 180 annuli on the body, one 181, one 182, three 183, two 185, two 186, one 187, one 188, one 189, one 190, one 195, and one 196; two have 18 annuli on the tail, eleven 19, and three 20. The "Porto-Bello" specimen has 189 annuli on the belly, and 19 on the tail. The number of annuli in five specimens of *A. cæca* (including the type) recorded by Strauch are respectively 212+15, 215+13, 227+18, 230+16, and 247+15. Duméril and Bibron give 226–329+18. A specimen from Porto Rico, which I owe to the

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[*] I am unable to find such a place either in the West Indies or Northern Brazil, but as the other of the two specimens presented by Capt. Austin as from "Porto Bello" belongs to a North-Brazilian species (*Amphisbæna vermicularis*), I entertain little doubt that both were obtained in Brazil.

kindness of Prof. Lütken, has 228+19. Considering that the number 247+15 given by Strauch is taken from a specimen in the Paris Museum, received from the Copenhagen Museum as from the island of St. Thomas, where only *A. fenestrata* (Cope) = *antillensis*, R. & L., is known to occur, as Prof. Lütken kindly informs me, it is clear to me that the specimen with 247 annuli belongs to *A. fenestrata*. The number of annuli would range, in *A. cæca* from 212 to 229, and in the present species from 180 to 196. According to Strauch, the length of the labial border of the first labial shield in *A. cæca* is about one half the length of that of the second; on Peters's figure of the type specimen, as well as in the Porto Rico specimen before me, it is about two thirds; in *A. Ridleyi* both are equal, or the former is a little longer. The snout is longer and somewhat more prominent, the tail thicker and more obtuse in *A. cæca* than in *A. Ridleyi*. The ventral segments of the two median rows are broader than long in the former species, the coloration of which is also different. I have therefore no hesitation in establishing a new species, which may be characterized as follows:—

Præmaxillary teeth 5 or 7, maxillaries 5–5, mandibulars 8–8. Snout obtusely pointed, slightly prominent. Tail thinner than the body, tapering. Rostral small, triangular; nasals forming a short suture; a pair of very large præfrontals, followed by a pair of much smaller frontals; eye hardly distinguishable through the ocular; a postocular, no subocular; three large upper labials, the second and third forming a suture with the ocular; lower border of second labial as long as or a little longer than that of the first, in contact with the second lower labial only; mental quadrangular, followed by a large seven-sided chin-shield, which is much longer than broad; three lower labials, second very large. 180 to 196 annuli on the body and 18 to 20 on the tail; the divisions of the annuli longer than broad, nearly equilateral on the middle of the belly, but nowhere broader than long; 16 to 18 divisions above, and 20 to 24 below the lateral line. Anal shields six or eight. Præanal pores four. Uniform brown or dark purplish brown above, pale brown inferiorly.

	millim.
Length to vent	250
Tail	24
Diameter of body	11

PISCES.

By G. A. Boulenger, F.Z.S.,
Assistant in the Zoological Department, British Museum.

The following marine species were obtained:—

Apogon imberbis, L., *Hæmulon chrysargyreum*, Günther, *Holocentrum longipinne*, C. & V., *Acantharus chirurgus*, Bl., *Dactylopterus volitans*, L., *Gobius soporator*, C. & V., *Salarias atlanticus*, C. & V., *Salarias vomerinus*, C. & V., *Clinus nuchipinnis*, Q. & G., *Clinus delalandii*, C. & V., *Gobiesox cephalus*, Lacép., *Pomacentrus leucostictus*, M. & T., *Glyphidodon saxatilis*, L., *Rhomboidichthys lunatus*, L., *Hemirhamphus unifasciatus*, Ranz., *Clupea humeralis*, C. & V., *Muræna pavonina*, Rich., *Muræna vicina*, Cast., *Muræna catenata*, Bl., and the new species described hereafter.

Julis noronhana, sp. n.

D. $\frac{8}{13}$. A. $\frac{2}{11}$. L. lat. 27. L. tr. $\frac{2\frac{1}{2}}{8}$.

Length of head one third of the total (without caudal), or a little less; depth of the body one fourth. Dorsal spines shorter than the rays. The length of the ventrals is two thirds or three fifths that of the pectoral, which is shorter than the head. Caudalis truncate. Upper half of body and caudal blackish, lower half yellowish white (in spirit); a whitish streak along each side of the back, just above the lateral line; dorsal, anal, pectoral, and ventral fins transparent, immaculate; a black spot between the first and third dorsal rays.

Several young specimens, the largest of which measures 60 millim.

The nearest ally of this species appears to be *J. lucasana*.

MOLLUSCA.

By Edgar A. Smith, F.Z.S.,
Assistant in the Zoological Department, British Museum.

The total number of Mollusca now known from Fernando Noronha is 80, of which 72 are marine forms, 7 terrestrial, and 1 freshwater.

Previous to this expedition no land or fluviatile species had been collected, and only 28 marine forms, all obtained by the 'Challenger,' have been recorded from this locality. Ten of these were also collected by Mr. Ridley, who has now added 44 additional species to the list.

The general facies of the marine Molluscan fauna is quite of a West-Indian type, as a perusal of the following pages will show; and it will also be observed that some of the species have a much wider and in some instances a very peculiar range. Of the land-shells two are known West-Indian species, one has been recorded from Brazil, Peru, and the island of Opara, and the remaining four, up to the present, appear to be peculiar to the island. One of these, however, *Bulimus Ramagei*, suggests a faunistic similarity to Brazil, as the section of *Bulimus* to which it belongs (*Tomigerus*), with one exception, occurs only in that country.

The single freshwater species suggests no relationship with any particular region, and might exist anywhere, similar forms being found both in the Old and New Worlds.

The following pages contain an account of the species obtained by Mr. H. N. Ridley and his colleagues, after which is appended a list of those recorded in the 'Challenger' Reports.

I. MARINE SPECIES.

1. OCTOPUS RUGOSUS, *Bosc.*

Hab. Mediterranean, Cape Verde Islands, West Indies, Rio Janeiro, &c.

This species is common in pools at low water. After being dried in the sun the arms are made into soup and eaten by the natives. Mr. Ridley, however, informs me that it is comparatively tasteless and of a soft gelatinous consistency.

2. CONUS NEBULOSUS, *Solander.*

Hab. West Indies: Barbados, Cuba, Martinique, Sta. Lucia.

The operculum of a shell 65 millim. in length is 17 long and only 4½ wide. It is thickened and carinate along the middle beneath, the muscular scar occupying more than half the entire length, and the nucleus is *not terminal* as stated by Messrs. Adams * and Tryon † in their respective Manuals of Conchology, but situated three millim. from the extremity. The growth at first is regularly concentric, but subsequently, to suit the narrowness of the aperture of the shell, the layers of increase are added at one end only, thus producing a long narrow operculum. MM. Cross and Marie[*] have also noticed, in respect of *C. imperialis*, *C. lividus*, and *C. rattus*, that the nucleus of the operculum is subapical, and doubtless it has a similar position in other species. The description of the operculum therefore as usually given in manuals and other works requires modification, and the nucleus should be termed ***apical*** or ***subapical***.

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* 'Genera of Recent Mollusca,' vol. i. p. 246.

† 'Structural and Systematic Conchology,' vol. ii. p. 187.

3. CONUS DAUCUS, *Hwass*.

Hab. Barbados (*Mus. Cuming*); St. Domingo and Guadaloupe (*Küster*); Cuba and Martinique (*d'Orbigny*).

The single beach-rolled specimen has a very strongly marked double zone of brown spots upon the middle of the body-whorl. With this species I unite *C. mammillaris*, Green, *C. castus*, Reeve (not *C. castus* of Weinkauff), *C. archetypus*, Crosse, and *C. sanguinolentus* of Reeve.

C. Reevei, Kiener, placed by Weinkauff[†] in the synonymy of this species, is quite a distinct shell, which I regard as the same as *C. piperatus*, Dillwyn, not *C. piperatus*, Reeve, which, as stated by Weinkauff, is the same as *C. erythræensis* of Beck.

4. PLEUROTOMA (CRASSISPIRA) FUSCESCENS, *Gray*.

1843. Pleurotoma fuscescens, *Gray, Reeve, Con. Icon.* fig. 125.
1845. Pleurotoma nigrescens, *Gray, Reeve, l. c.* fig. 235.
1845. Pleurotoma paxillus, *Reeve*, fig. 285.
1850. Pleurotoma solida, *C. B. Adams, Contrib. Conch.* vol. i. p. 61.

Hab. Cuba (*d'Orbigny*); Jamaica (*C. B. Ad.* for *solida*); St. Vincent (*Reeve* for *nigrescens*).

Pl. nigrescens and *Pl. paxillus* differ from the typical form of the species in being very much smaller, *Pl. solida* being intermediate in size.

In his 'Manual of Conchology' (vol. vi. p. 193) Tryon states that *Pl. nigrescens* of C. B. Adams and *Pl. nigrescens* of Gray are the same species. Having types of the former received from Adams and Gray's types also for comparison, I can state that beyond a doubt they are distinct. *Pl. cuprea*, Reeve, is rather an unsatisfactory species at present, and I am rather inclined to believe that, as suggested by Tryon, it will prove to belong to this species also.

[*] Journ. de Conch. 1874, pp. 333–359.

[†] Conch.-Cab. p. 312, no. 53.

5. Murex (Ocinebra) alveatus, *Kiener*.

Hab. Panama (*Reeve*, *Kobelt*, *Sowerby*); West Indies (*Tryon*).

As suggested by Tryon *, I think there must be some mistake with regard to the locality "Panama" which has been assigned to this species first of all by Reeve and afterwards by others. I have never seen a specimen from that locality, and Mr. G. B. Sowerby informs me that he has frequently received it with collections from the West Indies, but never from the Pacific side of Central America. ***M. erosus***, Broderip, ***M. obeliscus***, A. Adams, ***Triton Cantrainei***, Récluz, and probably ***M. pauperculus***, C. B. Adams, are perfectly distinct from the present species and from one another. This is another example of Tryon's rash and indiscriminate "lumping" of species, which detracts so much from whatever value may be attached to his work.

6. Pisania pusio (*Linné*).

Buccinum pusio, *Reeve*, *Con. Icon.* fig. 43.

Hab. Honduras and St. Thomas (*Coll. Cuming*); Sta. Lucia (*d'Orbigny* as *Purpura accincta*); Ascension I. (*Conry*).

The specimens from Fernando Noronha are rather small, and much more distinctly striated than certain examples from the West Indies.

7. Purpura hæmastoma, *Linné*.

The specimens obtained by Mr. Ridley constitute a well-marked variety of this well-known species, both as regards form and colour. They have the spire more elevated in proportion to the length of the aperture, and only the two uppermost of the four series of nodules on the body-whorl are distinct. The interior of the aperture is greenish blue, reddish near the labrum, which is bordered within with black-brown, upon which the fine orange or yellowish liræ are very distinct. The exterior of the shell is purplish black, streaked and spotted with greenish white. *P. hæmastoma* is known from the West Indies, West Africa, Mediterranean, Atlantic coasts of France, Spain, and Portugal.

8. Columbella mercatoria, *Linné*.

Hab. St. Vincent, Grenada, Nevis, Cuba, Martinique, and Sta. Lucia (*Brit. Mus.*).

With one exception the eleven Fernando Noronha shells are white, variegated with very dark brown or black. The single specimen, which differs from the rest, is of a pinkish tint sparingly marked with rich brown.

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* Man. Conch. vol. ii. p. 128.

9. OLIVA LITERATA, *Lamarck*.

Hab. West Indies, Gulf of Florida.

Two beach-rolled shells are all that were obtained. They have the transverse liræ on the inner lip extending over nearly the entire length of the columella.

10. OLIVA (OLIVELLA) NIVEA (*Gmelin*).

Hab. St. Vincent and other islands of the West Indies, Venezuela, and Brazil.

The shell named by Mr. Watson * *Oliva fulgida*, Reeve, from Fernando Noronha, does not belong to that species, but is a prettily coloured example of *O. nivea*. *O. fulgida* differs from Gmelin's species in the form of the columella and basal cauda. The columella of *O. nivea* is very peculiarly excavated, and this may be seen by looking as far within the aperture as possible. No such excavation occurs in *O. fulgida*, which also does not exhibit the numerous oblique folds or liræ on the columellar margin of the aperture which distinguish *O. nivea*.

A second species is quoted with doubt by Watson from Fernando Noronha, namely *O. pulchella*, Duclos. The two fragments referred to this species seem to me to bear little resemblance to Duclos's figure; but I have no hesitation in considering them specifically identical with the other specimen from the same spot which I refer to *O. nivea*.

11. LEUCOZONIA CINGULIFERA (*Lamarck*).

Hab. West Indies, Honduras, West Africa.

L. rudis, Reeve, is I consider quite distinct from this species. With this exception I agree with Tryon in his synonymy, and would even suggest the propriety of maintaining *L. leucozonalis*, Lamk., as a variety of this species.

The specimens from Fernando Noronha have stout rounded ribs, exhibit a distinct submedian white zone on the body-whorl, and have the aperture inclining to orange.

Tryon questions the West-African habitat of this species, but I am inclined to think it correct, as in the British Museum there are three specimens from that locality presented some years ago by a Mr. Lewis, together with other species which are undoubtedly West-African forms.

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* Gasteropoda of the 'Challenger' Exped. p. 224.

12. LEUCOZONIA OCELLATA (*Gmelin*).

Hab. West Indies.

The specimens obtained offer no differences from ordinary West-Indian examples.

13. LATIRUS SPADICEUS (*Reeve*).

A single young shell seems to belong to this species.

L. concentricus, Reeve, *L. brevicauda*, Reeve, *L. gracilis*, Reeve, and the present species are very closely related.

14. MITRA BARBADENSIS (*Gmelin*).

Hab. West Indies, Barbados, St. Vincent, &c.

M. tessellata, Kiener, which Reeve named *M. picta*, is perfectly distinct from the present species, and well known as a South-African shell. Tryon *, not possessing or not having seen the species, at once concludes, from their general superficial resemblance, that it must be the same as *M. barbadensis*. The sculpture of the two is quite different. *M. barbadensis* is ornamented with raised spiral lines, whilst *M. picta* exhibits transverse punctured striæ. The character of the outer lip also is quite different.

15. MITRA (PUSIA) ANSULATA, *Sowerby*.

Mitra ansulata, *Sowerby, Thes. Conch.* vol. iv. p. 26, pl. 373. fig. 474.

Mitra microzonias, *Reeve* (*non Lamarck*), *Con. Icon.* figs. 185, 202; *Sowerby, l. c.* fig. 635; *Kiener, Coq. Viv.* pl. 28. fig. 89 (probably); *Tryon, Man. Conch.* iv. p. 183, pl. 54. figs. 568, 569.

Hab. St. Thomas (*Mus. Cuming*); "West Indies, Mörch, Krebs, and Swift," *fide Tryon*.

This species is said to occur in Polynesia, but the British Museum Collection affords no evidence in proof of this statement.

The shell from Fernando Noronha belongs to that form of the species as figured by Reeve (fig. 185).

This is usually considered the *M. microzonias* of Lamarck, but if it be compared with the figure of that species in the 'Encyclopédie Méthodique' (pl. 374. fig. 8), it will be seen that it is a much more slender shell. The true *M. microzonias* has also been figured by Küster (Con.-Cab. pl. 17. figs. 12, 13), and Reeve also correctly depicts it (Con. Icon. pl. xxx. fig. 242 on left) under the name of *M. leucodesma*. Sowerby in his description of

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* Man. Conch. vol. iv. p. 118.

M. ansulata does not mention the presence of a second white zone on the body-whorl as represented in his figure, but this does occasionally exist. Tryon places this species in the synonymy of *M. dermestina*, Lamk., together with *M. cavea*, Reeve, *M. Adamsi*, Dobrn, *M. pulchella*, Reeve, *M. pisolina*, Lamk., *M. histrio*, Reeve, and *M. consanguinea*, Reeve. A more *ridiculous* instance than this of the "lumping" of species I have never seen. Tryon never could have examined examples of these various forms, for if he had he would not have united them; he must have been misled by the figures, or perhaps a little jealousy of non-possession may have influenced him.

Reeve's *M. leucodesma* he says is beyond a doubt the same as *M. pardalis*, Küster. From this it is, in my judgment, perfectly distinct; and the statement that "Reeve's figure of *M. pardalis* is a *Columbella*" is sheer guess-work. The shell figured by Reeve is in the British Museum, and not only is it a *Mitra*, but correctly identified by Reeve as *M. pardalis*, Küster. What right had Tryon to make such a statement in the face of Reeve's description, in which he properly characterizes the shell as *a Mitra with four plaits* on the columella? Numbers of similar absurdities occur throughout this work of Tryon's, which might have been avoided if more judgment had been used and the love of "lumping" been overcome.

16. MARGINELLA SAGITTATA, *Hinds*.

Hab. Bahamas to Brazil.

M. fluctuata, C. B. Adams, from Jamaica, appears to be the same as this species.

17. TRITON RIDLEYI, sp. n. (Plate XXX. fig. 1.)

Testa late fusiformis, albida, obsolete trizonata, zonis supra varices aurantiis; anfractus normales, superne declives et leviter concavi, ad medium biangulati, inferne constricti, costis longitudinalibus circiter 7 (in anfract. ultimo subtuberculiformibus inferne evanescentibus) instructi, liris spiralibus tenuibus (in anfr. penultimo 7–8) aliisque longitudinalibus tenuioribus concinne cancellati; apertura ovalis, alba; canalis brevis, dextrorsum versus; columella alba, superne arcuata, vix tortuosa, tuberculis vel liris transversis supra callum tenuem munita; labrum compresse varicosum, intus liris duodecim in paribus ordinatis instructum.

Longit. 19 millim., diam. 10.

This species belongs to the same group as *T. gallinago*, Reeve (Con. Icon. fig. 5), and *T. testudinarius*, Adams & Reeve, and some others. Although possibly not adult, the single shell at hand is in excellent condition, and affords all the necessary characters distinctive of the species. The last whorl has two varices, namely the labrum and one on the opposite side. The nuclear whorls are broken off; but, judging from the top of the first normal whorl, the apex would be comparatively small. The uppermost of the liræ on the columella is rather conspicuous, and, together with the uppermost of those within the labrum, forms a semicircular sinus above.

18. TRITON PILEARIS, *Lamarck*.

Hab. West Indies, Red Sea, Ceylon, Philippine Islands, island of Anna, &c. (*Brit. Mus.*).

This, like some other species of *Triton*, occurs at the West Indies and in the Indian and Pacific Oceans.

19. TRITON (EPIDROMUS) TESTACEUS, *Mörch*.

Hab. West Indies (*Mörch*).

This species is very like *T. obscurus*, Reeve, but differs in having more convex whorls, a granulated columellar callus, and a narrower labral varix which is also hollowed out behind.

20. CYPRÆA CINEREA, *Gmelin*, var.

Hab. West Indies.

With this species I unite *C. clara* of Gaskoin, with which the specimens from Fernando Noronha agree. This variety is of a longer and more cylindrical form than the type, has only traces of the black dotting around the base, and no purplish stain between the teeth. Sowerby's figure (Thes. Conch. pl. 307. f. 91*), badly copied by Tryon (Man. Conch. vol. vii. pl. 1. f. 8), does not represent the variety *clara*; but a fair representation of it is given by Sowerby on pl. 316, figure 222. The colour, however, is not pinkish, and no dotting occurs along the sides in the types described by Gaskoin.

21. CYPRÆA (TRIVIA) PEDICULUS, *Linné*.

Hab. West Indies.

One of the specimens from Fernando Noronha is remarkably small, measuring only 7 millim. in length.

22. LITTORINA TROCHIFORMIS, var.? (Plate XXX. fig. 2.)

Littorina trochiformis, *Dillwyn, Philippi, Abbild.* vol. ii. p. 143, pl. ii. ff. 12, 14, 15.

Littorina nodulosa, *Watson* (*non Gmelin*), '*Challenger*' *Gasteropoda*, p. 577.

Testa parva, fusiformi-ovata, grisea vel nigrescens, albo-nodosa; anfractus 6–7, convexiusculi, superiores granorum seriebus tribus ornati, striisque spiralibus elevatis paucis sculpti, ultimus in medio obtuse angulatus, seriebus quatuor cinctus, ad basim albo punctatus; apertura nigra, fascia basali pallida ornata, inferne subacuminata; columella lata, purpurea, superne macula lutescenti notata.

Longit. 19 mill., diam. 10. Apertura 7 longa, 6 lata.
„ 11 „ „ 9. „ 6½ „ 5 „

The above measurements of two specimens from Fernando Noronha show the variation in the form of this variety. The white tubercles are rather acute in some specimens, whilst in others they are scarcely raised above the surface. On the body-whorl there are two *approximated* series at the periphery and two above, and at the base is a tesselation of white and dark spots.

The shells quoted by Mr. Watson from Fernando Noronha are certainly specifically the same as those obtained by Mr. Ridley, and are, I think, almost specifically distinct from the *L. nodulosa* of d'Orbigny. They have less angular whorls and less acute nodules, of which there are *two* series on the body-whorl above the two principal series at the periphery, whilst in *L. trochiformis* (=*nodulosa*, d'Orb.) there is only a single series. The aperture, also, of the Fernando shells is darker and none of them exhibit a second pale zone at the upper part, which is nearly always visible in the West-Indian species.

23. LITTORINA ANGULIFERA (*Lamarck*).

Litorina angulifera, *Philippi, Abbild.* vol. ii. p. 223, pl. v. ff. 12–15.

Hab. West Indies, West Africa and Pacific (*Phil.*).

Only a single young specimen was obtained by Mr. Ridley; it agrees in all particulars with West-Indian specimens.

24. TORINIA ÆTHIOPS (*Menke*).

Hab. West Indies.

Both Philippi and Hanley, in their respective monographs, admit this as a distinct species, but I am inclined to think with the former* that *T. cyclostoma*, *T. nubila*, *T. cylindracea*, and the present species are mere varieties of one and the same form.

25. IANTHINA FRAGILIS, *Lamarck*.

Of the various species figured by Reeve, that which he has identified as Lamarck's *I. fragilis* (Conch. Icon. pl. ii. ff. 6 *a*, 6 *b*) closely resembles the shells from Fernando Noronha. They have the same perpendicular columella and the same division of colour, the "deep-violet" tint of the base terminating abruptly at the periphery.

26. CERITHIUM ATRATUM (*Born*).

Hab. West Indies, Pernambuco, and Rio Janeiro (*Brit. Mus.*).

I regard the *C. caudatum* of Sowerby as undoubtedly belonging to this species. "Sicily," the locality assigned by Sowerby in the 'Thesaurus Conchyliorum' and in Reeve's 'Conchologia Iconica' to *C. atratum*, is evidently incorrect.

27. MITRULARIA ALVEOLATA (*A. Adams*).

Calyptræa alveolata, *A. Adams, Reeve, Con. Icon.* vol. xi. pl. 3. ff. 8 *a–b*.

Hab. Galapagos Islands (*Reeve*); St. Kitts, West Indies (*Brit. Mus.*).

The single shell from Fernando Noronha possesses all the characteristics of the type from the Galapagos Islands. The specimens from Fernando Noronha, assigned with doubt to *M. uncinata*, Reeve, by Watson †, in all probability belong to the same species as that collected by Mr. Ridley. They are, however, only young specimens, so that their determination is all the more difficult.

28. HIPPONYX ANTIQUATUS (*Linné*).

Hipponyx antiquatus (*L.*), *Fischer, Journ. de Conch.* vol. x. p. 5, pl. ii. ff. 1–9 (anatomy); *Crosse, Journ. de Conch.* vol. x. p. 20; *Mörch, Malak. Blätt.* vol. xxiv. p. 98.

Hab. West Indies; islands of Ascension, St. Helena, and Trinidad in the South Atlantic, Peru and California (*Brit. Mus.*).

The single specimen from Fernando Noronha has the spire more recurved than any other specimen I have seen and it is inclined to the left.

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* Conch.-Cab., *Solarium*, p. 26.

† 'Challenger' Gastropoda, p. 461.

29. HIPPONYX GRAYANUS, var.

Hipponyx Grayanus, *Menke, Carpenter, Proc. Zool. Soc.* 1856, p. 4; *Crosse, Journ. de Conch.* 1862, vol. x. p. 23.

The distribution of this species appears to be very extensive. Carpenter quotes it from Galapagos, Sandwich Islands, Panama, S.W. Mexico, Mazatlan, and St. Vincent (W. Africa). Some specimens in the British Museum from St. Helena, wrongly named *H. radiatus*, Quoy & Gaimard, by Jeffreys *, and two specimens from Fernando Noronha agree in all respects with this species except in the more excentric position of the apex, which gives them a more capuliform appearance.

30. NERITA ASCENSIONIS, *Gmelin.*

In his monograph of *Nerita* in the Conchylien-Cabinet, Dr. von Martens mentions only the island of Ascension and Guinea as localities for this species. I had previously noted † the fact of its occurrence at the island of Trinidad off the Brazilian coast, and now I record its presence at Fernando Noronha, where it was also obtained by the 'Challenger' Expedition.

31. TURBO (CALCAR) OLFERSI, *Troschel.*

Trochus Olfersi, *Troschel, Philippi, Conch.-Cab.* ed. 2, p. 126, pl. 22. f. 1.

Calcar Olfersi, *Fischer in Kiener's Coq. Viv.* p. 18, pl. 77. f. 1.

Trochus digitatus, *Reeve* (*non Deshayes*), *Conch. Icon.* pl. 5. f. 24; *Sowerby, Thes.* vol. v. pl. 504. fig. 135.

Hab. Brazil (*Philippi & Fischer*).

The localities quoted by Reeve and Sowerby, namely Central America and Panama, will doubtless prove incorrect.

Failing to recognize this species as *T. Olfersi*, Sowerby has placed that name among the synonymy of *T. imbricatus*, which, however, is a perfectly distinct shell. *T. digitatus* of Deshayes, as pointed out by Philippi, Fischer, and Carpenter, is identical with the common *T. unguis*, Wood, of the Californian coast.

32. TROCHUS (EUTROCHUS) JUJUBINUS, *Gmelin.*

Hab. West Indies (*Philippi & Fischer*).

The two specimens from Fernando Noronha are more widely umbilicated than the shells figured by Reeve[*] and Fischer[†], and also differ in form, being wider at the base and more shortly conical.

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* Ann. & Mag. Nat. Hist. 1872, vol. ix. p. 264.

† *Ibid.* 1881, vol. viii. p. 431.

Fischer has already pointed out that the localities of Reeve and Lamarck, Swan River and Mauritius, are probably incorrect.

33. TROCHUS (EUTROCHUS) GEMMOSUS, *Reeve.*

This I believe, as in the case of the preceding species, is another instance of a wrong locality (Philippine Islands) assigned by Reeve.

Two specimens from Fernando Noronha agree in every minute detail with the types in the British Museum, and, as the sculpture and lineations are so remarkable, the identity is beyond doubt. The umbilicus, which is as large as that of *T. jujubinus*, at once distinguishes this species from *T. nobilis*, with which Philippi[‡] questioned its relationship. The type of *Eutrochus* was named *E. perspectivus* by A. Adams; but as that name was previously used by Koch for another species belonging to the same group, Pilsbury has renamed it *E. Adamsi.*

34. FISSURELLA CANCELLATA, *Sowerby.*

Fissurella cancellata, *Sowerby*, *Conch. Ill.* sp. 38, pl. 72. f. 29.

Hab. West Indies, Honduras.

With this species I would unite *Fiss. suffusa*, Reeve, and *F. lentiginosa*, Reeve. A third species of the same author, *F. ægis*, is also very similar, but the form is a little more elongate and the radiating riblets are squamose at the points of intersection with the concentric liræ.

35. FISSURELLA ALTERNATA, *Say.*

Fissurella alternata, *Say*, *Journ. Acad. N. Sci. Philad.* 1822, vol. ii. p. 224; *Reeve*, *Con. Icon.* pl. xii. f. 84 (probably).

Fissurella larva, *Reeve*, *l. c.* f. 98.

Fissurella Dysoni, *Reeve*, *l. c.* f. 86.

Hab. Maryland, &c. (*Say*); Bermuda, St. Johns, Honduras (*Brit. Mus.*).

The sculpture of the three above-named forms is essentially the same and the character of the orifice is similar, and all have the interior at the apex indented with a transverse line or pit at the larger end of the perforation, as described by Say.

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[*] Con. Icon., *Zizyphinus*, pl. 2. fig. 12.

[†] Kiener's Coq. Viv., *Trochus*, pl. 18. f. 2.

[‡] Conch.-Cab., *Trochus*, p. 86.

36. ? FISSURELLA BARBADENSIS, *Gmelin*.

Hab. West Indies.

There are two or three specimens from Fernando Noronha which closely approach this species, but I do not feel absolutely certain of the identification.

37. ? FISSURELLA NUBECULA, *Linné*.

Hab. Mediterranean, Spain, Morocco, coast of Gambia, Cape Verd Islands.

Several specimens from Fernando Noronha in some respects so closely resemble this species that I hesitate to separate them. The interior is of the same greenish tint, the orifice has a purplish tint or is ringed with purple, but the outer surface is uniformly darker than Mediterranean examples. With regard to sculpture it is difficult to say that any material difference exists, as specimens from any given locality exhibit slight variations in the fineness and number of the radiating striæ, such as may be noted in the series from Fernando Noronha.

38. ACMÆA NORONHENSIS, sp. n. (Plate XXX. figs. 3, 3 *a*.)

Testa ovata, postice latior, mediocriter elevata, nigrescens, radiis pallidis picta, ad apicem, paulo ante medium situm, erosa, nigra, radiatim tenuiter striata, lineisque incrementi sculpta; pagina interna intra cicatricem nigricans, apicem versus callo tenui sensim albicans, extra cicatricem fere ad marginem cæruleo-albida, ad marginem anguste nigro limbata, antice ab apice usque ad marginem radio lato obscuro et postice alio latiore picta.

Long. 24 millim., lat. 19, alt. 9.

This species has a smoother surface than *A. subrugosa*, d'Orbigny (=*Lottia onychina*, Gould), from Rio Janeiro. Like that species, however, it has in the interior a broad obscure ray from the apex to the margin in front and a broader one at the opposite end. These rays, however, are more distinct in the present species than in the Brazilian shell. The external radiating striæ being very fine, do not, as a rule, produce a crenulated margin, but in some instances a slight crenulation occurs. The surface within the muscular scar is almost black, forming a marked contrast to the pallid space between it and the black margin. The shells found attached to rocks, when placed upon a flat surface, rest upon the anterior and posterior margins only, so that the sides are slightly raised.

39. CHITON (ISCHNOCHITON ?) PECTINATUS, *Sowerby*.

Chiton pectinatus, *Sowerby, Con. Ill.* pl. 174. f. 146; *Reeve, Con. Icon.* pl. 26. f. 133.

Hab. ——? (*Reeve*); West Indies (*P. P. Carpenter in Brit. Mus.*).

The marginal scales are not at all well drawn by Sowerby, being much too elongate.

40. CHITON (ISCHNOCHITON) CARIBBÆORUM, *Carpenter*. (Plate XXX. figs. 5, 5*a*.)

Testa elongato-ovalis, vix carinata, varie picta, griseo-olivacea, albo, rufo et olivaceo picta, vel purpurea, interdum nigrescens, albo virgata, valvis terminalibus concentrice et rugose granoso-striatis vel squamatis, centralibus liris tenuissimis granosis curvatis flexuosis ornatis, areis lateralibus rugose granosis vel squamatis; valva postica pone apicem centralem leviter concava; cingulum minute squamatum, squamis minutis elongatis ovalibus indutum, pallide roseo-griseum, dilute nigro tessellatum.

Longit. 27 millim., diam. 9.

Hab. St. Thomas (*Brit. Mus.*).

The above appears to be a manuscript name attached to specimens in Cuming's collection which are identical with few shells from Fernando Noronha. The colour is very variable, some specimens, when viewed from a distance of twelve inches, appearing olive-grey speckled with white; others are of a pinkish cream-colour speckled with red or blotched along the sides in front of the lateral areas with black, as in some of the specimens from Fernando Noronha. The granules or scales of the lateral area and on the front and posterior valves are peculiarly flat and are somewhat transversely arranged on the former and concentrically on the latter. The central areas are finely punctured along the centre, and become more and more coarsely granosely lirate as the sides are approached. One example is almost entirely reddish purple, and others are blackish with a broad pallid stripe down the middle from end to end.

41. CHITON (ACANTHOCHITON) ASTRIGER, *Reeve*.

Chiton astriger, *Reeve, Conch. Icon.* pl. xviii. f. 109.

Hab. Barbados.

Reeve describes this species as "smooth along the summit, very closely finely striated on each side." This is not at all accurate. The central portion of the non-terminal valves has a defined elongate subtriangular space which is sculptured with minutely granular lines, and the sides are densely but rather more coarsely granulated. The figure (47) of the detail of sculpture of *C. spiculosa*, Reeve, which I believe to be the same species, gives quite as good an idea of the ornamentation as figure 109. The outer margin of the mantle bears a fringe of the same glassy spicules as compose the tufts.

42. DORIS, sp.

A single specimen was obtained, which appears to belong to the same species as an unnamed example in the British Museum from the West Indies.

43. APLYSIA, sp.

An animal about an inch long is all that was found. It probably is not full-grown. No attempt has been made to identify either this or the preceding, as both belong to difficult groups requiring special study.

44. SIPHONARIA PICTA, var.?* (Plate XXX. figs. 4–4*b*.)

Hab. Rio Janeiro (*d'Orbigny*).

The specimens from Fernando Noronha are externally blackish with numerous white radiating costæ. The inner surface also is much darker than in the type specimens from Brazil. *S. hispida*, Gould, also from Rio Janeiro, appears to be the same species. *S. lineolata*, d'Orbigny, from Cuba, is a larger form, and the only species that appears to have been discovered in the West Indies. One or two species are known from Bermuda (*S. brunnea*, Hanley); and Say has described a form from East Florida.

45. VENUS (ANAITIS) PAPHIA, *Linné*.

Hab. West Indies and Cape Verd Islands (*Brit. Mus.*).

46. CARDIUM SUBELONGATUM, *Sowerby*.

Hab. St. Thomas, West Indies.

47. CARDIUM MEDIUM, *Linné*.

Hab. West Indies.

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* D'Orbigny, Voy. Amér. Mérid.' vol. v. p. 469, pl. 56. ff. 7–11.

48. SEMELE CORDIFORMIS, *Chemnitz.*

1766. Tellina reticulata, *Linné?*, *Syst. Nat.* ed. 12, p. 1119.

1795. Tellina cordiformis, *Chemnitz*, *Conch.-Cab.* vol. xi. p. 208, pl. 199. ff. 1941-2.

1815. Tellina decussata, *Wood*, *Gen. Conch.* p. 190, pl. 43. figs. 2, 3.

1822. Amphidesma orbiculata, *Say*, *Journ. Acad. Nat. Sci. Philad.* vol. ii. p. 307; *Reeve*, f. 13.

1826. Amphidesma radiata, *Say*, *l. c.* vol. v. p. 220; *Reeve* (as of *Rüppell*), f. 12.

1832. Amphidesma lenticularis, *Sowerby*, *Proc. Zool. Soc.* 1832, p. 200; *Con. Ill.* f. 9; *Reeve*, f. 39.

1841. Amphidesma reticulata, *Sowerby*, *Con. Illust.* p. 8; *Reeve*, f. 29.

1841. Amphidesma subtruncata, *Sowerby*, *l. c.* p. 7.

1845. Amphidesma Jayanum, *C. B. Adams*, *Proc. Bost. Soc. Nat. Hist* vol. ii. p. 10.

1853. Semele sinensis, *A. Adams*, *Proc. Zool. Soc.* 1853, p. 95; *Reeve*, f. 28.

1853. Semele luteola, *A. Adams*, *l. c.* p. 95; *Reeve*, f. 42.

1853. Semele modesta, *A. Adams*, *l. c.* p. 95; *Reeve*, ff. 35 *a-b*.

1853. Amphidesma cordiformis, *Reeve*, *Con. Icon.* f. 30.

Hab. West Indies, Bermuda, Rio Janeiro, Ascension Island, St. Helena, Cape Palmas, and Fernando Po (*Brit. Mus.*).

Having carefully studied a large series of specimens from the above localities, the types of *S. lenticularis*, said to have been obtained in West Colombia, also the types of *S. chinensis*, *S. reticulata* (Sow.), *S. subtruncata*, *S. luteola*, and *S. modesta*, also the specimens figured by Reeve, I am inclined to believe that all the above-named forms constitute but a single variable species.

Some authors have considered this species to be the *Tellina reticulata* of Linné; but I am rather inclined to think, with Hanley, that there is not sufficient evidence to determine this with any degree of certainty. The locality "China," from which Adams named a form *S. sinensis*, I regard simply as one more of the innumerable errors of "habitat" occurring in Cuming's collection.

49. CHAMA, sp. incert.

Several specimens of a species of *Chama* were taken on the rocks; but the surfaces are so eroded and water-worn, that it is impossible to determine them.

50. Mytilus exustus (*Lamarck*), *Reeve*.

This is a West-Indian species, and was also obtained by the 'Challenger' expedition at Fernando Noronha and Pernambuco*.

51. Arca imbricata, *Bruguière*.

This species was also obtained by the 'Challenger' Expedition at Fernando Noronha; and other examples were dredged near Cape York, N. Australia. This seems a remarkable distribution; still, as far as I can discover, there appears to be no difference in the shells.

52. Arca (Acar) Adamsii, *Shuttleworth*, *MS.*?—Arca Adamsi *in Cuming's Collection*. (Plate XXX. figs. 6, 6 *a*.)

Testa oblonga, subquadrata, sordide albida, inæquilateralis, antice curvata, postice oblique arcuata, inferne in medio levissime sinuata, lineis elevatis radiantibus aliisque concentricis cancellata; umbones parvi, parum remoti, paulo ante medium collocati; area dorsalis angusta, utrinque acuminata; ligamentum minimum, adamantiforme, transversim striatum; pagina interna alba, radiatim plus minus substriata.

Longit. 12 millim., alt. 7½, diam. 7½.

Hab. St. Vincents, Jamaica, and St. Thomas (*Brit. Mus.*).

Two specimens bearing the above name occur in Cuming's collection, and others from Jamaica presented by Dr. P. P. Carpenter are also similarly labelled; but I have not succeeded in finding any description by Shuttleworth of this species.

It is closely related to *A. lactea*, Linn., *A. solida*, Sowerby, and some others. The points of contact of the radiating and concentric liræ are nodulous, and a little coarser than in either of the above-named species. The muscular impressions are clearly defined by a raised ridge which is continued upward towards the umbones.

53. Lima squamosa, *Lamarck*, var.

Hab. Atlantic, Pacific, and Indian Oceans.

The distribution of this species is given in my Report upon the 'Challenger' Pelecypoda. The specimens from Fernando Noronha seem intermediate between *L. squamosa* and *L. multicostata*, having fewer ribs than the latter, and more than typical examples of the former.

A specimen 22 millim. long has twenty-six ribs, and another example 16 millim. in length has but twenty-one.

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* *Vide* 'Report on 'Challenger' Lamellibranchiata, p. 272.

54. SPONDYLUS, sp.

A few odd valves picked up on the shores are too much worn to be identified with certainty. About a dozen forms have been described as West-Indian; and doubtless it is one or more of these species which occur at Fernando Noronha.

II. TERRESTRIAL SPECIES.

1. HELIX (OPHIOGYRA?) QUINQUELIRATA. (Pl. XXX. figs. 7–7*c*.)

Testa discoidea, supra leviter convexa, inferne anguste umbilicata, tenuis, viridi-flavescens, nitida; aufractus 7, lente accrescentes, convexi, incrementi lineis striati, supra peripheriam indistincte concavus, antice haud descendens, intus plicis tribus inæqualibus perlucentibus munitus, lamellisque duobus validis parietalibus instructus; apertura semilunata, parva; peristoma tenue, haud expansum.

Diam. maj. 6 millim., min. 5½, alt. 3.

Hab. Found, both living and dead, at the north end of the island, also on Platform Island.

H. entodonta, Pfeiffer, from Ecuador, is an allied form; but has a flatter spine, more open umbilicus, and no parietal liræ.

2. BULIMUS (TOMIGERUS) RAMAGEI, sp. n. (Plate XXX. fig. 8.)

Testa subovata, rimata, solida, fusca, zonis angustis albis transversis (in anfr. ultimo quatuor) cincta; anfractus 5, convexiusculi, lineis incrementi subrugosis, striisque tenuissimis spiralibus sculpti, ultimus magnus, antice descendens, post labrum contractus, scrobiculatus; apertura irregularis, longitudinis totius ½ paulo superans, dentibus quatuor inæqualibus (duobus parvis in pariete aperturali, uno magno compresso in margine dextro, uno tuberculiformi valido in margine columellari) munita; peristoma album, valde incrassatum, leviter reflexum, marginibus callo craso junctis.

Longit. 23½ millim., diam. 16.
„ 17½ „ „ 12½.

The above measurements show that considerable difference exists in the size of specimens; and it is a curious fact that the smallest example, obtained from a native, is the only one which appears in fairly fresh condition. All the rest were found by Mr. Ramage imbedded in sandy mud on a raised reef at Tobacco Point, and have a semi-fossilized appearance.

The only forms at all approaching that now described are the species of *Tomigerus*, all of which, however, have a much more complicated oral dentition, and are of different form, with the last whorl ascending, and other marks of distinctness.

In general form and texture of the shell it is not at all unlike *Pythia inflata*, Pfeiffer; but of course has not the expanded lip or the same dentition as that genus.

Two only of the twenty specimens which I have examined exhibit any variation in the teeth of the aperture. These want the two parietal denticles.

3. BULIMUS (BULIMULUS) RIDLEYI, sp. n. (Plate XXX. fig. 9.)

Testa parva, ovata, superne acuminata, umbilicata, fusca, ad peripheriam luteo-lineata; anfractus 5–6, convexiusculi, lineis incrementi striisque spiralibus tenuissimis sculpti, ultimus antice haud descendens; apertura ovata, intus fusco-carnea, linea pallide mediana ornata, longit. totius ½ ad æquans; peristoma undique expansum, carneo-albidum, marginibus callo tenui (interdum crasso) superne subtuberculiformi junctis.

Longit. 12 millim., diam. 6.

Hab. Living under bark of Mango-trees in the garden and on the north side of the island; also found at the base of the Peak, north side, under stones, and on Rat Island.

I do not know any species sufficiently near this form wherewith to offer a comparison. It resembles somewhat in form certain species of *Partula*; it faintly recalls, chiefly on account of colour, *Bulimus Jacobi*, from the Galapagos Islands; and the spiral striation, although finer, somewhat resembles that of some of the species of the genus *Plecotrema*.

4. PUPA SOLITARIA, sp. n. (Plate XXX. figs. 10, 10 *a*.)

Testa minuta, rimata, albida, ovato-cylindracea; anfractus 5, convexi, striis incrementi tenuibus sculpti, sutura vix obliqua sejuncti, ultimus pone labrum subvaricosus; apertura parva, quinque-dentata; dente valido duplici columellari, uno minore etiam duplici in pariete aperturali, duobus parvis ab margine dextro remotis, quinto minuto basali; peristoma anguste expansum, album, marginibus callo tenui junctis.

Longit. 2⅓ millim., diam. 1¼.

Hab. Platform Island.

This species is a trifle less cylindrical than *P. pellucida*, Pfeiffer, a Cuban species; but has the number of teeth and their arrangement similar. The columellar tooth, however, is double, the upper portion of it being most prominent; the tooth above it upon the body-whorl is single, bifurcating at the end. The three remaining teeth are rather remote from the margin of the aperture. The anterior part of the last whorl just behind and parallel to the labrum exhibits a longitudinal swelling or varix, towards which the lip expands.

5. STENOGYRA (OPEAS) OCTONOIDES, *C. B. Adams.*

Hab. Jamaica, Cuba, St. Thomas.

This species is more strongly striated than *S. subula*, has rounder whorls, a deeper suture, and a larger apex.

Four specimens were obtained at Platform Island.

6. STENOGYRA (OPEAS) SUBULA, *Pfeiffer.*

Hab. Cuba, Porto Rico, &c.

The specimens from Fernando Noronha agree exactly with examples of this species from Porto Rico. They were found beneath stones on the promontory between Chaloupe Bay and S. Antonio Bay.

7. STENOGYRA (OPEAS) BECKIANA, var.

Hab. Island of Opara, Peru, Brazil.

The shells from Fernando Noronha, obtained at the same spot as the preceding species, answer well to Pfeiffer's description; but they are *more strongly costulate* than Brazilian specimens with which I have compared them.

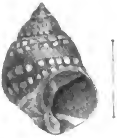
III. FRESHWATER SPECIES.

1. PLANORBIS NORONHENSIS, sp. n. (Plate XXX. figs. 11–11 *b.*)

Testa parva, valde compressa, superne in medio depressa, inferne subplanulata, albida, tenui, subpellucida; anfractus 4, superne convexiusculi, striis incrementi tenuissimis sculpti, inferne radiatim subplicati, ad suturam angustissime marginati, ultimus infra medium obtuse carinatus; peristoma tenue, marginibus callo filiformi junctis, superiore oblique arcuato.

Diam. maj. 5 millim., min. 4⅓, alt. 1.

This species is about the same size and shape as *P. Gilberti*, Dunker, and *P. fragilis*, Brazier, from Australia. The lower surface, however, is flatter, and the curve of the lip different



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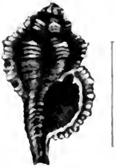

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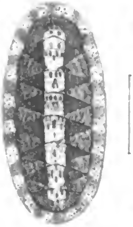

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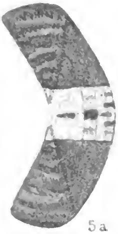

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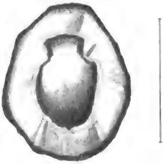

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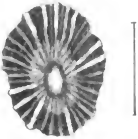

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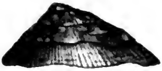

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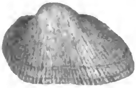

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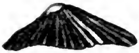

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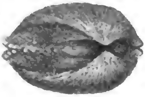

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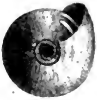

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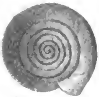

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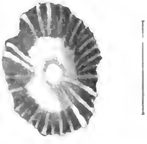

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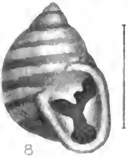

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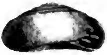

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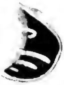

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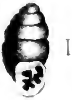

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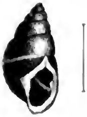

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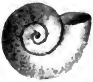

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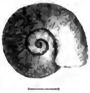

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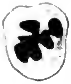
11 b



10a

M. Fisher del.

Mintern imp.

MOLLUSCA OF FERNANDO NORONHA

when viewed from above. It was very plentiful in the lake on the south-west corner of the island.

List of Species obtained at Fernando Noronha by the 'Challenger' Expedition.

Acmæa, sp.
Littorina nodulosa, *d'Orb.*
Nerita ascensionis, *Gmelin.*
Cerithiopsis, sp.
Columbella mercatoria, *Linn.*
Cylichna noronyensis, *Watson.*
Fossarus ambiguus (*Linn.*).
Marginella sagittata, *Hinds.*
Mitrularia uncinata (*Rve.*).
Nassa capillaris, *Watson.*
Oliva fulgida, *Reeve.*
—— pulchella (?), *Duclos.*
Phasianella, sp.
Rissoa, sp.
Scalaria hellenica, *Forbes.*
Siphonodentalium tetraschistum, *Watson.*
Solarium, sp.
Stomatella nigra, *Quoy & G.*
Utriculus canaliculatus (*Say*).
Xenophora corrugata (*Reeve*).
Chiton Boogii, *Haddon.*
Pectunculus pectinatus (*Gmelin*).
Ervilia subcancellata, *Smith.*
Cardium medium, *Linné.*
Lucina pecten, *Lamarck.*
Mytilus exustus, *Rve.*
Arca imbricata, *Brug.*
Pecten noronhensis, *Smith.*

For the above species, see the Reports on the Gasteropoda, Polyplacophora and Lamellibranchiata, by R. B. Watson, A. C. Haddon, and E. A. Smith respectively.

EXPLANATION OF PLATE XXX.

Fig. 1. *Triton Ridleyi*, sp. n.
2. *Littorina trochiformis*, var.
3, 3 *a*. *Acmæa noronhensis*, sp. n.
4–4 *b*. *Siphonaria picta*, var.
5. *Chiton* (*Ischnochiton*) *carribæorum.*
5 *a*. Ditto. Central valve, magnified.
6, 6 *a*. *Arca* (*Acar*) *Adamsii.*
7–7 *c*. *Helix* (*Ophiogyra?*) *quinquelirata.* 7 *c*. Aperture, enlarged; lip broken away to show the teeth.
8. *Bulimus* (*Tomigerus*) *Ramagei*, sp. n.
9. „ (*Bulimulus*) *Ridleyi*, sp. n.
10. *Pupa solitaria*, sp. n. 10 *a*. Aperture, enlarged.
11–11 *b*. *Planorbis noronhensis*, sp. n.

POLYZOA.

By R. Kirkpatrick,
Assistant in Zoological Department, British Museum.

POLYZOA.

The specimens chiefly encrust shells, and are generally much worn away.

1. Aetea recta, *Hincks.*
2. Synnotum aviculare, *Pieper.*
3. Scrupocellaria frondis, n. sp.
4. Cribrilina radiata, *Moll.*
5. Smittipora antiqua, *Busk.*
   (*Mollia antiqua*, Smitt.)
6. Steganoporella Smittii, *Hincks.*
7. Mastigophora Dutertrei, *Audouin.*
8. Schizoporella unicornis, *Johnston.*
9. Lepralia depressa, *Busk.*
   (*Escharella rostrigera*, Smitt.)
10. Lepralia cleidostoma, *Smitt.*
11. Rhynchopora bispinosa, *Johnst.*—(Encrusting *Gorgonia* axis.)
12. Cellepora Ridleyi, n. sp.
13. Microporella violacea, *Johnst.*—Encrusting *Gorgonia* axis; (both purple and white varieties).
14. Crisia Holdsworthii, *Busk.*
15. Amathia brasiliensis, *Busk.*

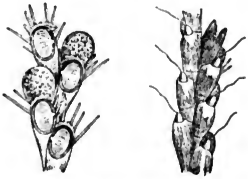
Family Cellulariidæ.

Genus Scrupocellaria.

Scrupocellaria frondis, n. sp.

Zoœcia of medium size, alternate; area oval, occupying nearly half the front of cell; spines 2–4 on the outer side, 2 on the inner; lowermost spine on outer side bending over the top of the aperture and giving off processes from its upper border; operculum entire, large, oval, marked with concentric striæ; on some cells a small pointed avicularian cell projecting from the front of the cell; lateral avicularia wanting; on dorsal surface vibracula, small, flattened, obliquely placed; setæ long. Oœcia small, globose, vitreous, punctured.

Fig. 1.



Scrupocellaria frondis, n. sp.

The presence of the antler-like spine across the top of the area is a marked character of *S. frondis*.

Loc. Fernando Noronha; Pernambuco.

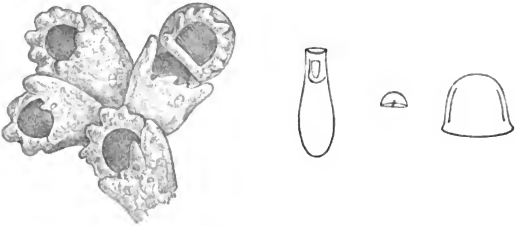
Family CELLEPORIDÆ.

Genus CELLEPORA.

CELLEPORA RIDLEYI, n. sp. (Fig. 2, p. 506.)

Zoarium loosely encrusting; zoœcia decumbent, rectangular, and flattened at the margins, heaped, somewhat ventricose subvertical in the centre, separated by raised lines; orifice from semicircular to subquadrate, with concave proximal margin; two or three short processes surrounding the orifice; at base of an anterior process a small avicularium facing inwards, with small semicircular mandible. On the front of some cells a small avicularian cell with small rounded mandible. Oœcium shaped like a thick semi-disc, concave below, overhanging the mouth of the cell; mucronate processes on the upper surface; front wall of oœcium with a semicircular membranous area on the front wall.

Fig. 2.



Cellepora Ridleyi, n. sp.

The oœcium of *C. Ridleyi* is remarkable in its shape and relations to the zoœcium; also there is a curious resemblance between the membranous area and the orifice of the zoœcium.

Loc. Fernando Noronha.

CRUSTACEA.

By R. I. Pocock,

Assistant in the Zoological Department, British Museum.

Introductory Remarks.—The fauna is in all essential respects allied to that of the mainland and of the Antilles. The following wide-spread forms were, as might have been expected, met with:—*Grapsus maculatus*, *Leiolophus planissimus*, *Hippa scutellata*, *Alpheus Edwardsii*, and *Gonodactylus chiragra*. There are two new species of *Alpheus*, one of *Panulirus*, and one of *Stenopusculus* (*S. spinosus*). The last mentioned genus has hitherto only been known from the island of Mauritius; its occurrence here, therefore, is of great interest. A new freshwater Ostracod was also obtained.

DECAPODA.

MAIOIDEA.

Family PERICERIDÆ.

Genus MICROPHRYS, *M.-Edwards.*

1851. Microphrys, *M.-Edwards, Ann. Sci. Nat. Zool.* 3, xvi. p. 251.
1879. Microphrys, *Miers, Journ. Linn. Soc.* (*Zool.*) xiv. p. 664.
1881. Microphrys, *A. M.-Edwards, Miss. Sci. Mex.* (*Crust.*) p. 59.

MICROPHRYS BICORNUTUS (*Latreille*).

1825. Pisa bicornuta, *Latreille, Encycl. Méth. Hist. Nat.* x. p. 141.
1872. Microphrys bicornutus, *A. M.-Edwards, Nouv. Arch. Mus. Hist. Nat.* viii. p. 247.
1881. Microphrys bicornutus, *id. Miss. Sci. Mex.* (*Crust.*) p. 61, pl. xiv. figs. 2, 3, 4.

Nine specimens, six males and three females (two with ova).

This species is common on the coasts of Florida, Mexico, and of the West-Indian Islands. Occurred under stones and on coral-reef.

Genus MITHRAX (*Leach*).

1817. Mithrax (*Leach*), *Latreille, Règne Animal,* iii. p. 23.
1834. Mithrax, *Milne-Edwards* (in pt.), *Hist. Nat. Crust.* i. p. 317.
1879. Mithrax, *Miers, Journ. Linn. Soc.* (*Zool.*) xiv. p. 667.

MITHRAX VERRUCOSUS, *M.-Edwards.*

1832–38. Mithrax verrucosus, *M.-Edwards, Mag. Zool.* vii. pl. 4.
1881. Mithrax verrucosus, *M.-Edwards, Miss. Sci. Mex.* p. 102.

Four specimens, two males and two females (one with ova).

The largest specimen (a male), with the following measurements of carapace, width 42 mm., length 35 mm., differs considerably from the others, of which the smallest (the female with ova) gives the following measurements of carapace:—width 17 mm., length 15 mm. In the three small specimens all the spines are sharper and relatively longer, and the carpus of the chelipedes is armed above with four or five minute spines in addition to the three spines which adorn its anterior (interior) margin.

Brazil and the West Indies are localities given for this species. Under stones at Morro do Chapeo.

MITHRAX (TELEOPHRYS) CRISTULIPES (*Stimpson*).

1862. Teleophrys cristulipes, *Stimpson, Ann. Lyc. Nat. Hist.* vii. p. 190 pl. ii. fig. 2.

1881. Teleophrys cristulipes, *A. M.-Edwards, Miss. Sci. Mex.* (*Crustacea*), p. 113, pl. xix. fig. 2.

Regions of the carapace defined by shallow sulci. Superior surface of body and limbs tubercular, inferior surface smooth.

Carapace broader than long, beset with low, inconspicuous, scattered tubercles which vary in distinctness. The principal tubercles arranged as follows:—two or three on each half of the rostrum between the superior orbital prominences, one on each side of the middle line at the base of the rostrum, two in longitudinal series on each side of the gastric region, several on the branchial regions, and three on the anterior lateral margin of each. Orbit furnished in front with a superior and an inferior blunt prominence. Not furnished with spines or prominences behind.

Rostrum short, broad, with upturned anterior margin, not deeply bifid, marked above with central sulcus, and separated on each side from the superior orbital prominence by a conspicuous depression. Its anterior margin projecting slightly beyond the middle of the basal segment of the antennæ and slightly in front of the inferior orbital prominence.

Chelipedes large; merus tubercular above and furnished below in front with three large, rounded, compressed teeth; carpus furnished above with four or five tubercles, and with one blunt tooth in front. Hand smooth; its distal portion compressed above and below into a crest. Dactylus and pollex meeting only at the apices. Dactylus furnished with a single tooth.

In the first pair of legs the merus is furnished above with two longitudinal rows of prominences, the posterior row consisting of lower rounded tubercles, which distally decrease in size, the anterior row of five higher, compressed, sharper teeth, which distally increase in size; distal margin of the segment produced into five rounded prominences, varying in size; the carpus, in addition to three or four low tubercles on its centre, with its distal margin furnished with a larger anterior and a smaller posterior tubercle, and its antero-superior surface with a larger proximal and a smaller distal tooth; propodos furnished above with two tubercles, one near the centre, the other at its distal margin; claw long, curved, hairy below, with its distal portion serrate below.

The arrangement of tubercles and teeth upon the second, third, and fourth pairs of legs is nearly the same as the arrangement upon the first pair, but the posterior row of meral tubercles becomes progressively fainter from before backwards, and the teeth of the anterior row become gradually modified in form and number until, in the posterior pair of limbs, this row is formed of four teeth, two larger and two smaller, the larger and smaller alternating, and one of the larger being the most proximal of the series. Width of carapace 7½ mm., length 7 mm.

One male specimen was obtained.

To guide me in the identification of the Fernando-Noronha specimen, which I refer to *T. cristulipes* (Stimps.), I have had to trust to the descriptions and figures of that species published by Dr. Stimpson and by M. Alphonse Milne-Edwards, and to my own examination of a single imperfect individual which was taken off Cape St. Lucas (California), and presented to the British Museum by the Smithsonian Institute.

Now, although with the above-mentioned figures and descriptions the specimen from Fernando Noronha does not present agreement in all points, yet, making allowance for possible errors on the part of the artists, I should unhesitatingly have referred this specimen to *T. cristulipes* (Stmps.) were it not for the fact that the points of difference between it and the specimen from Cape St. Lucas are by no means inconsiderable.

In the Californian specimen the sulci defining the regions of the carapace are conspicuously deeper, and the tubercles of the same part, though exhibiting in the main the same arrangement, are much larger. This is especially the case with regard to those of the branchial region, the three low tubercles of the antero-lateral margin in the Noronha specimen being represented in the Californian specimen by three large upstanding teeth. Again, with regard to the limbs, the merus of the chelipede in the Californian specimen is furnished below in front with one large compressed tooth and the pollex is armed with two small teeth, these small teeth being scarcely represented in the Noronha specimen. The other limbs present much the same arrangement of teeth in the two specimens, but, as in the case of the carapace, the teeth of the Californian specimen are relatively larger than those of the Noronha specimen.

I am well aware that the differences thus set forth are amply sufficient to justify the separation as distinct species of the specimens which they characterize; yet having but one example from each locality, I am unable to determine the constancy of the differences presented, and must consequently leave the decision of the question as to the specific identity or distinction of the two to those whom either the possession of a long series of forms or a more perfect acquaintance with this group of Crustacea places in a better position to judge than myself.

I am not aware that this species, or at all events any closely allied form, has before this been recorded from the eastern coast of America. Stimpson obtained it from Cape St. Lucas and M. Alphonse Milne-Edwards has described it from the Bay of Panama.

MITHRAX (MITHRACULUS) CORONATUS (*Herbst*).

1782. Cancer coronatus, *Herbst, Naturg. der Krabben*, i. p. 184, pl. xi. fig. 63.

1881. Mithraculus coronatus, *A. Milne-Edwards, Miss. Sci. Mex.* (*Crustacea*), p. 106, pl. xx. fig. 1.

Eight males and seven females (three with ova) were taken.

This species occurs on the coasts of Brazil, Central America, and of the West-Indian Islands. Its presence in Fernando Noronha has been previously mentioned by Mr. E. J. Miers, two small specimens having been obtained from that island during the voyage of H.M.S. 'Challenger.'

CANCROIDEA.

Family CANCRIDÆ.

Genus CARPILIUS (*Leach, MS.*), *Desmarest*.

1825. Carpilius, *Desmarest, Consid. gén. sur la classe des Crust.*, footnote, p. 104.

1834. Carpilius, *Milne-Edwards* (pt.), *Hist. Nat. Crust.* i. p. 380.

1865. Carpilius, *A. Milne-Edwards* (pt.), *Nouv. Arch. Mus. Hist. Nat.* i. p. 212.

1886. Carpilius, *E. J. Miers, Brachyura of H.M.S. 'Challenger,'* p. 110.

CARPILIUS CORALLINUS (*Herbst*).

1782. Cancer corallinus, *Herbst, Naturg. der Krabben*, i. p. 133, pl. v. fig. 40.

1865. Carpilius corallinus, *A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat.* i. p. 216.

Three specimens, two males and one female.

This species is the West-Indian representative of the genus. [These crabs are exported in wooden crates filled with dry leaves to Pernambuco, where they are in great demand as food. We were told they were land-crabs.—*H. N. R.*]

Genus ACTÆA, *de Haan.*

1850. Actæa, *de Haan, Crust. in Siebold, Fauna Japonica,* dec. i. p. 18.

ACTÆA ACANTHA, *Milne-Edwards.*

1834. Cancer acanthus, *M.-Edwards, Hist. Nat. Crust.* i. p. 379.

1881. Actæa acantha, *A. M.-Edwards, Miss. Sci. Mex.* (*Crust.*) p. 245, pl. xliii. fig. 1.

One minute specimen, a male, was obtained.

It is only comparatively lately that the locality of this species has been made known by M. Alphonse Milne-Edwards, who received a specimen of it from Guadeloupe.

Genus LEPTODIUS, *A. Milne-Edwards.*

1863. Leptodius, *A. Milne-Edwards, Ann. Sci. Nat., Zool.* sér. 4, xx. p. 283.

1873. Leptodius, *A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat.* ix. p. 221.

1886. Leptodius, *Miers, Brachyura of H.M.S. 'Challenger,'* p. 136.

LEPTODIUS AMERICANUS (*Saussure*).

1858. Chlorodius americanus, *H. de Saussure, Mém. sur divers Crust. nouv. du Mex. et des Antilles,* p. 14, pl. i. fig. 5.

1881. Leptodius americanus, *A. Milne-Edwards, Miss. Sci. Mex.* (*Crust.*) p. 269.

Of this species eight specimens (5 males, 3 females with ova) were obtained. It is found in the West Indies and Florida.

Genus LOPHACTÆA, *A. Milne-Edwards.*

1862. Lophactæa, *A. Milne-Edwards, Ann. Sci. Nat., Zool.* sér. 4, xviii. p. 43.

1865. Lophactæa, *A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat.* i. p. 245.

1886. Lophactæa, *E. J. Miers, Brachyura of H.M.S. 'Challenger,'* p. 113.

LOPHACTÆA LOBATA, *Milne-Edwards.*

1834. Cancer lobatus, *Milne-Edwards, Hist. Nat. Crust.* i. p. 375.

1865. Lophactæa lobata, *A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat.* i. p. 249, pl. xvi. fig. 3.

A single male specimen. This is a West-Indian and Mexican species.

GRAPSOIDEA.

Family OCYPODIDÆ.

Genus OCYPODA, *Fabricius*.

1798. Ocypoda, *Fabricius* (pt.), *Ent. Syst. Suppl.* p. 347.
1837. Ocypoda, *Milne-Edwards, Hist. Nat. Crust.* vol. ii. p. 41.
1880. Ocypoda, *Kingsley, Proc. Acad. Nat. Sci. Philad.* p. 179.
1886. Ocypoda, *Miers, Brachyura of H.M.S. 'Challenger,'* p. 237.

OCYPODA ARENARIA (*Catesby*).

1771. Cancer arenarius, *Catesby, Hist. of the Carolinas*, ii. p. 35, pl. xxxv.

1880. Ocypoda arenarius, *Kingsley, Proc. Acad. Nat. Sci. Philad.* p. 184.

1882. Ocypoda arenarius, *Miers, Ann. Mag. Nat. Hist.* ser. 5, x. p. 384, pl. xvii. fig. 7.

Five adult specimens (four males and one female).

[Common in holes in the sand at Sueste Bay and Sambaquichaba.—*H. N. R.*]

Family GRAPSIDÆ.

Genus GRAPSUS, *Lamarck*.

1818. Grapsus, *Lamarck* (pt.), *Hist. Nat. Anim. sans Vert.* v. p. 247.
1880. Grapsus, *Kingsley, Proc. Acad. Nat. Sci. Philad.* p. 192.
1886. Grapsus, *Miers, Brachyura of H.M.S. 'Challenger,'* p. 254.

GRAPSUS MACULATUS (*Catesby*).

1771. Pagurus maculatus, *Catesby, Nat. Hist. Carolinas*, ii. p. 36, pl. xxxvi. fig. 1.

1880. Grapsus maculatus, *Kingsley, Proc. Acad. Nat. Sci. Philad.* p. 192.

This species has a very wide range, occurring upon the coasts of the warmer temperate and tropical parts of the Indian, Pacific, and Atlantic Oceans. It is exceedingly variable, and the extent of variation is well shown by the specimens brought from Fernando Noronha.

Five immature and two adult males were obtained; the former are of a dark green colour with feeble indications of *maculæ*, the latter red-brown with maculæ well developed. [Very common on the rocks all over the group, running briskly just above water-mark and leaping from stone to stone.—*H. N. R.*]

Genus PLAGUSIA, *Latreille*.

1806. Plagusia, *Latreille* (pt.), *Gen. Crust. Ins.* i. p. 33.
1837. Plagusia, *Milne-Edwards*, *Hist. Nat. Crust.* ii. p. 90.
1878. Plagusia, *Miers, Ann. Mag. Nat. Hist.* ser. 5, i. p. 148.
1886. Plagusia, *Miers, Brachyura of H.M.S. 'Challenger,'* p. 271.

PLAGUSIA DEPRESSA (*Fabricius*).

1775. Cancer depressus, *Fabricius, Syst. Ent.* p. 406.
1782. Cancer squamosus, *Herbst, Naturg. der Krabben,* i. p. 260, pl. xx. fig. 113.
1878. Plagusia depressa, *Miers, Ann. Mag. Nat. Hist.* ser. 5, i. p. 149.

[This ran about on the stones and rocks like the *Grapsus*.—*H. N. R.*]

Genus LEIOLOPHUS, *Miers*.

1850. Acanthopus, *de Haan, Faun. Japon., Crust.*, p. 29 (nom. præocc.).
1876. Leiolophus, *Miers, Cat. New-Zeal. Crust.* p. 46.
1878. Leiolophus, *Miers, Ann. Mag. Nat. Hist.* ser. 5, i. p. 153.

LEIOLOPHUS PLANISSIMUS (*Herbst*).

1804. Cancer planissimus, *Herbst, Naturg. der Krabben,* iii. Heft 4, p. 3, pl. lix. fig. 3.
1878. Leiolophus planissimus, *Miers, Ann. Mag. Nat. Hist.* ser. 5, i. p. 153.

A single specimen (female with ova) of this wide-spread form was taken.

PORCELLANIDEA.

Family PORCELLANIDÆ.

Genus PETROLISTHES, *Stimpson*.

1859. Petrolisthes, *Stimpson, Proc. Acad. Nat. Sci. Philad.* x. p. 227.

PETROLISTHES MARGINATUS, *Stimpson*.

1862. Petrolisthes marginatus, *Stimpson, Ann. Lyc. Nat. Hist. New York*, vii. p. 74.

I have had no opportunity of examining specimens of *P. marginatus* (Stimpson), and consequently not being certain of the correctness of the identification of the specimens that I have referred to that species, I have thought it desirable to publish a description of them which may, so far as is possible, furnish a test as to the accuracy of the conclusion that has been arrived at.

Carapace and upper surface of limbs pubescent. Width of carapace approximately equal to its length. Carapace smooth, punctured; its anterior half furnished laterally with a small, sharp, upstanding spine. From this spine there extends backwards into the posterior half of the carapace a granular ridge which serves to separate the superior portion of the carapace from the lateral portion. The frons is slightly depressed and is marked off from the hinder portion of the carapace by a distinct ridge, which runs transversely between the posterior margins of the orbits. In the middle this ridge is interrupted by a conspicuous sulcus, which extends to the central lobe of the frons. This lobe is rounded anteriorly; its lateral margins are nearly vertical to the remainder of the anterior margin of the frons and approximately parallel to the superior margin of each orbit, which is the lateral border of the frons. The anterior half of this lateral border marked off from the posterior half by being at a conspicuously lower level.

Basal segment of antenna furnished on the inner side with a small acute spine.

Upper surface of chelipede covered with more or less squamiform granules; lower surface smooth. Anterior margin of upper surface of meral segment produced into a sharp process; beneath this, on the under surface, is a sharp spine, which may be bifid; posterior margin of upper surface spined. Anterior margin of upper surface of carpal segment furnished with three or four sharpened processes; posterior margin spined and produced distally into a spined process. The middle of the upper surface bearing a longitudinal series of larger squamiform tubercles. Inferior border of anterior surface of carpal segment granular; rest of the surface smooth. Anterior and posterior margins of manus and dactylus granular. A slightly curved series of larger squamiform granules extending along the upper surface of the manus from its carpal to the middle of its dactylar joint. Continuous with this is a series running from the base to the apex of the dactylus. Apex of dactylus and of thumb smooth and curved.

Anterior and posterior margins of meral segments of second, third, and fourth pairs of legs spined; posterior margin of second and third pairs produced distally into a small acute spine.

Colour (of specimens preserved in spirit of wine) red or yellow above, with darker spots, reddish pink beneath.

Three specimens. Length and width of carapace in largest specimen 14 mm.; length of manus and pollex 20 mm.

The specimens that I have here described and identified provisionally as *P. marginatus* (Stmps.) are evidently closely allied to *P. asiaticus* (Leach), the common Indo-Pacific form, and I am doubtful if they should be regarded other than as varieties of that species.

HIPPIDEA.

Family HIPPIDÆ.

Genus REMIPES, *Latreille*.

1806. Remipes, *Latreille, Gen. Crust. Ins.* i. p. 45.
1837. Remipes, *Milne-Edwards, Hist. Nat. Crust.* ii. p. 204.

REMIPES SCUTELLATUS (*Fabricius*).

1793. Hippa scutellata, *Fabricius, Ent. Syst.* ii. p. 474.
1858. Remipes cubensis, *H. de Saussure, Mém. sur Crust. nouv. du Mex. et des Antilles*, p. 36, pl. ii. fig. 19.
1878. Remipes scutellatus, *Miers, Journ. Linn. Soc.* (*Zool.*) xiv. p. 319.

The species occurs on the tropical coasts of the Atlantic.

Twenty-three specimens, two of which are females with ova, were taken. [Very common on the sandy shores. When a wave broke, these little crustacea were often seen running and burying themselves in the sand as the water retired.—*H. N. R.*]

THALASSINIDEA.

Family GEBIIDÆ.

Genus GEBIA.

1816. Gebia, *Leach, art.* Annulosa, *Edinb. Encycl.* vii. p. 419.
1837. Gebia, *Milne-Edwards, Hist. Nat. Crust.* ii. p. 312.

GEBIA SPINIGERA, *S. I. Smith*.

1869. Gebia spinigera, *Smith, Rep. Peabody Acad. Sci.* p. 92.

Eight specimens, one female with ova, were brought back.

The species was originally described from specimens obtained upon the west coast of Central America.

ASTACIDEA.

Family PALINURIDÆ.

Genus PANULIRUS, *Gray*.

1847. Panulirus, *Gray, Cat. Brit. Mus.* (*Crust.*) p. 69.
1852. Panulirus, *Dana, Crust. U.S. Expl. Exp.* i. p. 519.

PANULIRUS ECHINATUS, *S. I. Smith*.

1869. Panulirus echinatus, *Smith, Trans. Connecticut Acod.* ii. p. 20.

Five specimens were taken, two adult females, one with ova, and one immature female, one adult male and one immature male.

The specimens described by Smith were from Pernambuco.

PANULIRUS ORNATUS (*Fabr.*).

1798. Palinurus ornatus, *Fabricius, Ent. Syst. Suppl.* p. 400.
1837. Palinurus ornatus, *M.-Edwards, Hist. Nat. Crust.* ii. p. 296.
1867. Palinurus ornatus, *Heller, Reise Freg. Novara, Crust.* p. 99.

In 1872 v. Martens, in his paper "Ueber cubanische Crustaceen," Arch. f. Naturg. xxxviii. p. 128, recorded the occurrence on the eastern coasts of America of a *Palinurus*, which he questionably identified as *P. ornatus* (Oliv. ?), a species which appears to have its head-quarters in the Indo-Pacific Seas. From Fernando Noronha, Mr. Ridley obtained one specimen of a *Panulirus*, which I cannot separate by any important character from *P. ornatus* (Fabr.); and in addition to this specimen there is in the British Museum Collection one other from Panama, which is also, I believe, referable to *P. ornatus* (Fabr.). It will thus be seen that this form occurs in the Indo-Pacific Seas and upon the east and west coasts of America.

It is perhaps of interest to note that the spines upon the carapace and upon the peduncles of the antennæ appear to be somewhat sharper, and relatively longer, in the American individuals than they are in the Eastern individuals that I have had an opportunity of examining.

[Tolerably common, and collected from the rock-pools for food.—*H. N. R.*]

PANULIRUS INERMIS, n. sp.

Carapace somewhat flattened above, with sides nearly vertical. The right and left portions of the upper surface meeting in the middle line at a very obtuse angle. Carapace nearly smooth frontal spines considerably shorter than the eye-stalks, slightly incurved at the apices, armed above at the base with a single spine; one spine situated near the ocular margin of the carapace, one in the anterior third of the supero-lateral margin, and a third beneath the eye-stalk near the outer portion of the basal antennal segment.

Antennal peduncle about two thirds the length of the carapace; basal segment armed externally with a single spine on its anterior margin; second segment armed above with five spines, two forming a longitudinal series externally, three forming an oblique series internally; third segment armed above with ten short spines. Below, the three segments are smooth.

Antennular plate nearly horizontal, with rounded antero-external angles not armed with spines; the peduncle shorter than peduncle of antennæ; segments of peduncle not spined.

Epistoma with a straight unspined anterior margin.

The first and fifth pairs of limbs simple, unspined. (Second, third, and fourth pairs absent.)

Postero-external angles of the sternum prolonged into a sharp, long spine.

Abdominal tergites smooth, punctured, not marked with a transverse sulcus; inferiorly and laterally prolonged into a spine. The posterior margin of the last dorsal plate furnished with two long, sharp spines.

Proximal portion of telson furnished in the middle of its upper surface with two spines and with its posterior margin armed on each side with four spines.

Total length from anterior margin of carapace to posterior margin of telson 27 millim. Length of upper surface of carapace 11 millim.

One specimen.

Judging from its size, the specimen from which the above description has been taken is certainly immature. It, nevertheless, presents the characters of a true *Panulirus*, and differs from all the specimens of that genus that I have examined in the absence of spines from the basal plate of the antennulæ. Dredged in Water Bay. About 10 fathoms depth.

CARIDEA.

Family PALÆMONIDÆ.

Genus ALPHEUS (*Fabricius*).

1798. Alpheus, *Fabricius, Ent. Syst. Suppl.* p. 380.

1878. Alpheus, *Kingsley, Bull. U.S. Geol. Surv.* iv. p. 189.

ALPHEUS EDWARDSII (*Aud.*).

1809. Athanasus Edwardsii, *Audouin, Explic. planches de Savigny, Descript. de l'Egypte, Atlas,* pl. x. fig. 1.

1818. Alpheus heterochelis, *Say, Journ. Acad. Nat. Sci. Philad.* i. p. 243.

1884. Alpheus Edwardsii, *Miers, Rep. Crust. H.M.S. 'Alert,'* p. 284.

Twenty-nine specimens. This species is common in the warmer parts of the Atlantic, Pacific, and Indian Oceans, and in consequence of its wide range and of the variations to which individuals are subject it possesses a long list of synonyms. These synonyms may be found upon reference to the above cited work of Mr. E. J. Miers.

ALPHEUS MINOR, *Say.*

1818. Alpheus minus, *Say, Journ. Acad. Nat. Sci.* i. p. 245.

1837. Alpheus minus, *Milne-Edwards, Hist. Nat. Crust.* ii. p. 356.

1878. Alpheus minus, *Kingsley, Bull. U.S. Geol. Geogr. Surv.* iv. p. 190.

One specimen.

This species occurs upon the east and west coasts of America. Kingsley records it from N. Carolina, Bermudas, Florida on the east, and from Pearl Island Bay (Panama) on the west.

ALPHEUS RIDLEYI, n. sp.

Carapace and abdominal tergites smooth; carapace furnished in front with a short pointed rostrum, which does not nearly reach to the second segment of the antennular peduncle; rostrum separated by depression from the ocular hoods, each of which is furnished with a spine projecting in front as far as the extremity of rostrum.

Antennular spine reaching nearly to the second segment of the peduncle, which is the longest of the three, the third being the shortest.

Antennal scale as long as antennal peduncle, longer than antennular peduncle; basal segment of antenna furnished beneath with a strong spine.

Terminal segment of external maxillipede hairy.

First pair of legs very unequal in size. Dactylus of larger hand closing vertically, with evenly rounded supero-anterior border, without accessory teeth; its greatest length equal to one half of the length of the superior margin of the manus. Anterior margin of the "thumb" on the inner side nearly vertical, forming an obtuse angle with the inclined superior margin. Superior and inferior margins of thumbs on the outer side nearly parallel; in front united by a distinct anterior border, which below curving forwards forms with the inferior border the tooth of the thumb, which does not project so far forwards as the anterior margin of the dactylus.

Upper margin of the manus with a very faint constriction in its anterior half; right and left sides smooth, without depressions; lower margin with a very faint depression in its anterior half; upper margin marked with sulcus, which in the middle of the hand curving downwards and backwards runs to the carpal joint. Carpus rounded above, not bearing a tooth; meros three-sided, flattened below, not bearing a tooth above in front. Smaller manus simple, without constrictions or depressions; dactylus, thumb, and upper margin of manus approximately equal in length; carpus furnished with a blunt tooth above, equal in size to the carpus of the larger manus; meros resembling the meros of the larger manus.

In the second pair of legs the first carpal segment is as long as the second and the third together; third about half the length of the second, equal in length to the fourth, shorter than the fifth, which itself is shorter than the second.

Meros and carpus of third and fourth pairs of legs not spined.

In size and form resembling *A. Edwardsii*, but differing from it in having the larger hand very lightly constricted above and below. Moreover, there is a large black spine on each side of the telson.

ALPHEUS PANAMENSIS, *Kingsley*.

1878. Alpheus panamensis, *Kingsley*, *Bull. U.S. Geol. Surv.* iv. p. 192.

Carapace smooth, furnished in front with a strong rostrum, which projects considerably beyond the spines of the orbital hoods, almost as far as the second segment of the antennular peduncle; separated by a depression from the ocular hoods, each of which is furnished with a small sharp spine.

Lower margin of hood continuous below the spine.

Antennular spine reaching slightly beyond the margin of the basal segment of the peduncle. Second segment of peduncle longer than the third, as long as the first.

Antennal scale and peduncle as long as each other, and slightly longer than the antennular peduncle. Basal segment of antenna furnished below with a strong sharp spine.

First pair of legs very unequal in size. Dactylus of larger hand closing vertically, its greatest length being more than half the length of the superior margin of the manus; without accessory teeth.

Anterior margin of the thumb on the inner side nearly vertical, meeting the inclined superior margin at an obtuse angle; less than half the length of the superior margin. Thumb on the outer side without a vertical anterior margin, the superior margin meeting the inferior at an acute angle and forming the tooth.

Manus smooth, without constrictions or depressions, longer than the carapace; superior and inferior margins nearly parallel. Carpus rounded above, not bearing a tooth. Meros three-sided, flattened below; superior margin produced in front into a blunt process.

Smaller manus simple; dactylus and thumb approximately equal in length to each other and to the manus.

Carpus furnished above on the inner side with a small projection. Meros resembling meros of larger limb, except that the front process is smaller.

In second pair of limbs the carpal segments are 1, 2 and 5, 3 and 4.

First segment almost as long as the second, third, and fourth together. Second segment a little shorter than the third and fourth together, these being approximately equal; fifth as long as the second.

Meros and carpus of third and fourth pairs of legs not spined. Dactyli of limbs not bifid.

One specimen. If I am right in referring this species to *Al. panamensis* of Kingsley, with the description of which it agrees well, it is of interest to note that it occurs upon the eastern and western coasts of America. Mr. Kingsley described his specimens from Panama and Acajutla.

ALPHEUS OBESO-MANUS, *Dana*.

1852. Alpheus obesomanus, *Dana, U.S. Expl. Exped., Crustacea*, i. p. 547, pl. xxxiv. fig. 7.

Carapace smooth, furnished in front with a short rostrum, which does not reach nearly so far as the anterior border of the first segment of the antennula, but a little beyond the ocular hoods, from which it is separated on each side by a deep sulcus. Ocular hoods not spined, but slightly produced in front.

Antennular spine short, not reaching to the front margin of the first segment of the peduncle of the antennula. Second segment of peduncle the longest of the three, the third the shortest.

Antennal scale as long as peduncle of antennula, shorter than peduncle of antenna. Basal segment of antenna without a spine.

Legs of first pair very unequal in size. Dactylus of larger manus closing horizontally, about half as long as the upper margin of the manus. The superior (outer) margin of the thumb furnished with two large teeth, of which the posterior is smaller, more slender, and with a blunt apex, the anterior having a rounded margin.

Dactylus short, rounded. Dactylus and thumb very hairy.

The manus simple, cylindrical, without constrictions or depressions, as long as the carapace and the two proximal segments of the antennular peduncle. Carpus deep from above downwards, rounded above, and not furnished with a tooth. Meros deep from above downwards, three-sided, flattened below; upper margin produced in front into a conspicuous process.

Smaller hand somewhat resembling the larger, except that it is less twisted, less cylindrical, with dactylus and thumb straighter and relatively longer. Carpus less deep, and furnished on the upper inner margin with a distinct nodule. Meros less deep, with upper tooth scarcely conspicuous.

In the second pair of legs the carpals are 2, 5, 4 and 3 and 1. The first, third, and fourth segments approximately equal in length, the fifth a little longer; the second as long as the third, fourth, and fifth together. In the third and fourth pairs of legs the carpus and meros are below furnished in front with a strong spur.

Ten specimens. So far as I know, this species has not been hitherto recorded from the American coasts. Its occurrence has been mentioned in the Samoan Islands (*Kingsley*), Fiji Islands (*Dana*, *Miers*), and in Mauritius (*Richters*).

ALPHEUS ROSTRATIPES, n. sp.

Carapace smooth, anterior margin crescentically excavated, the sides of the excavation being formed by the ocular hoods, which are anteriorly produced but not furnished with spines, and not separated from the rostrum by a depression. Rostrum springing from the centre of the excavation, pointed, short, projecting slightly in front of the ocular hoods, but not reaching the anterior margin of the first segment of the antennular peduncle. Antennular spine reaching to the middle of the second segment of peduncle. Segments of peduncle short, approximately equal in length; second segment furnished externally with a small spine on its anterior margin. Antennal scale as long as the antennular peduncle, much shorter than the antennal peduncle. Basal segment of antenna furnished laterally with a conspicuous spine.

One of the legs of the first pair absent. The dactylus of the remaining one (the smaller ?) closing vertically; long, longer than the manus, curved, pointed blade-like, when closed; crossing the thumb. Thumb almost as long as dactylus, and at the base twice as thick, gradually tapering to a sharp, upturned point, meeting manus at an obtuse angle. Manus elliptical, simple, without constrictions or depressions, furnished close to the dactylar joint on each side with two blunt teeth, those on the outer side being obscurely marked. Carpus furnished on its inner side with a small blunt tooth. Meros three-sided, flattened below, superior margin produced in front into a conspicuous projection. Carpals of the second pair of legs becoming progressively shorter in the following order:—1, 5, 2, 3, 4.

Carpus and meros of third and fourth pairs not furnished below with a spine. Dactylus of fourth pair bifid, of third pair absent.

ALPHEUS, sp.

(Too mutilated for identification.)

Carapace furnished in front with a small pointed rostrum, which projects slightly in front of the ocular hoods, but not nearly to the anterior margin of the basal segment of the peduncle of the antennula; ocular hoods rounded and not spined. Basal spine of antennula reaching to the anterior margin of the basal peduncular segment. Second segment of peduncle longer than the third, approximately equal to the first. Antennal scale longer than the antennular peduncle, shorter than the peduncle of the antenna. Basal segment of antenna not provided with a spine.

Legs of first pair absent.

Carpals of the second pair differing upon the two sides, on the right side the fifth segment being longer than the second, and on the left side shorter. In each case the first is the longest, and the third and fourth the shortest.

Carpus and meros of third and fourth pairs not produced below into a tooth.

Dactyli of third, fourth, and fifth pairs simple.

ALPHEUS, sp.

(Too mutilated for identification.)

Carapace furnished in front with a short rostrum, which does not project as far as the middle of the first segment of the peduncle of the antennula, and is separated by a depression on each side from the ocular hoods. Each ocular hood furnished with a spine. Antennular spine short, sharp, not reaching to the front margin of the basal segment of the peduncle. Second segment of the peduncle the longest, the first and third approximately equal in length. Antennal scale as long as antennal peduncle, a little longer than antennular peduncle. Basal segment of antenna furnished with a long, sharp spine, which projects as far as the middle of the second segment of the antennular peduncle.

First and second pairs of legs absent. Carpus and meros of third and fourth pairs not produced below in front into a strong process. Dactyli of third, fourth, and fifth pairs bifid.

[The *Alphei* were taken in numbers from the holes in which they hid by breaking up the coral-reef.—*H. N. R.*]

Family PENÆIDÆ.

Genus STENOPUSCULUS, *Richters.*

1880. Stenopusculus, *Richters, Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen, von Möbius, Richters und v. Martens,* p. 167.

STENOPUSCULUS SPINOSUS, n. sp.

? Syn. Stenopusculus crassimanus, *Richters, t. c.* p. 168, pl. xviii. figs. 27–29.

Upper portion of cephalothorax sparsely spined; spines in front of the cervical suture larger than those behind it. Posterior margin of the cervical suture furnished above with 4 or 5 spines, and laterally with 3 or 4 larger ones. Postero-lateral portions of cephalothorax almost smooth; antero-lateral portions beset with spines arranged more or less in longitudinal series. Anterior marginal excavation adjoining the basal antennal segment armed with four spines.

Cephalothorax furnished in front with a pointed rostrum, which starts upon the anterior half of the cephalic portion of the carapace and reaches almost as far forwards as the front margin of the antennular peduncle. Upon each side the rostrum extends horizontally over the basal portion of the eye. Furnished above with eleven teeth, of which five are larger than the rest, and below near the apex with one tooth.

Proximal portion of antennular peduncle furnished externally with a strong curved spine; upper surface of peduncle with three spines; under surface with four on the inner margin and one on the outer margin.

Basal segment of antennal peduncle furnished above with two spines externally, and with a laminate process internally; second segment covered by the basal segment, furnished below with three spines; third segment with one spine externally and with three internally. External margin of antennal scale with five or six fine teeth, internal margin fringed; antennal scale somewhat triangular, laminate, projecting slightly in advance of the antennal peduncle, which is approximately as long as the antennular peduncle.

Epistome furnished with four strong teeth.

Ischial segment of external maxillipede furnished distally with three spines externally, and with one spine internally; meral segment externally with three strong spines. Internal margin of all the segments clothed with hairs.

Segments of first and second pairs of legs simple, more or less cylindrical, unspined.

Meropodite of third pair of legs cylindrical, spined, with some larger sharp spines near the distal extremity on the inner surface. Carpopodite rounded below, flattened and hollowed above; the hollowed portion with a few small spines, the rest thickly spined; spines on the outer surface larger.

Inner surface of the hand covered with small tubercles; outer surface almost smooth, with a few small tubercles near the upper and under margins. Upper margin compressed into a serrated keel; under margin also serrated. Anterior margin of hand nearly at right angles to the axis of the pollex. Pollex upturned at the apex, furnished on its occludent margin with a tooth which closes behind the tooth of the dactylopodite. Upper margin of dactylopodite serrated.

Fourth and fifth pairs of limbs resembling each other in being slender and elongated, in having the propodite furnished below with a series of fine spines and consisting of three segments, and in having the dactylopodite bifid. But whereas the propodite of the fourth pair consists of five segments, the propodite of the fifth pair consists of but three. The number of divisions of these segments, however, appears to vary upon the two sides.

Abdominal tergites smooth above; lateral portions narrowed, somewhat pointed, and with margins more or less spined.

The outer and inner lamellæ of appendages of the sixth abdominal somite with a median longitudinal crest, serrate exterior margin, and fringed inner margin. Outer margin of inner lamella furnished below with a stronger tooth.

Telson with converging lateral margins, rounded posterior margin; each lateral margin furnished with a central tooth; posterior margin furnished with three teeth, one on each side and one in the middle. Upper surface of telson marked with two longitudinal crests, each of which bears three spines arranged longitudinally; the depression between the crests furnished proximally with four spines in two longitudinal series. Base of telson bearing on each side one marginal spine.

Two specimens.

Length from apex of rostrum to posterior margin of telson 13 millim.; total length of upper surface of carapace (including rostrum) 5½ millim.; length of manus and pollex of third pair of feet 8 millim.

This species seems to differ from *St. crassimanus*, Richters, in the possession of a greater number of teeth upon the rostrum and in the absence of a crest upon the abdominal tergites.

The three species which hitherto have, so far as I am aware, composed the genus were taken at Touquets (Mauritius).

STOMATOPODA.

Genus Gonodactylus, *Latreille.*

1825. Gonodactylus, *Latreille, Encycl. Méth. Hist. Nat.* x. p. 473.
1837. Gonodactylus, *Milne-Edwards, Hist. Nat. Crust.* ii. p. 528.
1880. Gonodactylus, *Miers, Ann. Mag. Nat. Hist.* v. p. 115.
1886. Gonodactylus, *Brooks, Stomatopoda of H.M.S. 'Challenger,'* p. 55.

Gonodactylus chiragra (*Fabricius*).

1793. Squilla chiragra, *Fabricius, Ent. Syst.* ii. p. 513.
1880. Gonodactylus chiragra, *Miers, Ann. May. Nat. Hist.* v. p. 115.

Fourteen specimens of this widely distributed species were brought back. In the coral-reef.

MYRIOPODA.

By R. I. Pocock,
Assistant in the Zoological Department, British Museum.

The island does not seem to be rich in members of this group, since four species only were obtained in it. Two of these appear to be new to science, one being referable to the genus *Geophilus*, the other to the genus *Spirobolus*. The others are the two widespread tropical species, *Scolopendra morsitans* (Linn.) and *Paradesmus gracilis* (C. Koch).

Chilopoda.

Scolopendra morsitans (*Linn.*), emend., *Kohlrausch, Arch. f. Naturg.* 1881, p. 104.

Thirteen specimens were taken. Common under dung and stones, at the east end of the main island and base of Peak Garden and elsewhere. The bite is about as bad as a wasp's sting.

Geophilus Ridleyi, n. sp.

Length 44 millim. Width about 1 millim. Posterior end of the body slightly more slender than the anterior.

Ochraceous, head-plate slightly darker.

Number of pairs of legs 73 (in the female).

Antennæ hirsute, the distal end more so than the proximal. Segments of the proximal half cylindrical, those of the distal half narrowed proximally; apical segment as long as the two preceding segments.

Head-plate with straight anterior margin, rounded lateral margins, and concave posterior margin; sparsely clothed with hairs, and almost destitute of punctures.

Frontal lamina coalesced with rest of head-plate.

Basal lamina about twice as wide as long, with abruptly converging lateral margins and concave anterior margin. The prebasal lamina visible in the space left between the concave posterior border of the head-plate and the concave anterior border of the basal lamina.

Maxillary sternite wider than long; its anterior margin slightly excavated, but scarcely bidentate.

Maxillary feet largely visible from above, and projecting slightly in front of the head-plate; the segments on the inner side furnished with hairs but not armed with teeth.

Dorsal plates conspicuously bisulcated.

Ventral pores occupying a circular area in the posterior half of the sternites.

Legs sparsely clothed with longish hairs.

The anal tergite wide, but not covering the pleuræ; with rounded postero-lateral angles, staight posterior margin, and lateral margins slightly converging behind.

Anal pleuræ smooth, not furnished with punctures.

Anal sternite very wide at the base, gently converging lateral borders, rounded posterior angles and straight posterior margin.

Anal pores conspicuous. Anal legs broken.

A single female specimen, found under a stone in the Sapate.

This species appears to be closely allied to *G. occidentalis*, Meinert (Proc. Amer. Phil. Soc. xxiii. p. 220), from San Francisco; but differs in the absence of teeth from the segments of the maxillary feet, and in the absence of pores from the anal pleuræ.

DIPLOPODA.

PARADESMUS GRACILIS (*C. Koch*).

Two female specimens.

For the synonymy and an excellent description of this species, see Dr. Robert Latzel's 'Die Myriopoden der öst.-ungar. Monarchie,' ii. p. 162.

This very wide-spread form occurs in the East and West Indies and Brazil.

It has been introduced, in connection with tropical plants, into Europe; and I have examined many specimens of all ages, which were captured in the conservatory of Mr. Alfred O. Walker at Chester, and in the orchid-houses of Mr. Herbert Druce at St. John's Wood.

[It was very common in the garden.—*H. N. R.*]

SPIROBOLUS (s. s.) **NORONHENSIS**, n. sp.

Length about 30 millim. Number of somites 37.

Colour deep slate-grey or almost black; anterior half of each somite (the first and last excepted) adorned above and below on each side with a single reddish spot. Legs and labrum reddish.

Distal portion of the head-plate furnished with a faint median longitudinal impression, upon each side of which, near the margin of the labrum, are two setiferous punctures, one near the middle line, the other near the external portion of the labral excavation. Distal segments of antennæ pilose.

First dorsal plate smooth, without striæ; laterally, where the anterior and posterior margins pass into one another, evenly rounded; furnished with a fine sulcus which runs from near the ocular region of the head-plate, close to the antero-inferior margin, and terminates at the postero-inferior margin.

Foramina repugnatoria situated, somewhat dorsally, in the posterior portion of the somites. Posterior portion of each somite smooth above; anterior portion marked with transverse striæ; inferior and lateral portions marked with numerous longitudinal striæ. Somites not furnished with the '*scobina*.'

Posterior somite smooth; produced behind into a blunt rounded process, which extends slightly beyond the margins of the anal valves. Anal valves with margins not compressed. Margin of subanal plate rounded.

The right and left moieties of the male copulatory apparatus held together in front by a triangular plate. Below this plate terminates in a rounded apex, which extends as far as the inferior margins of the halves of the apparatus. Each upper angle of this plate produced laterally and upwards into a relatively slender bar, which curves round the superior portion of the anterior lamina of its side. Each anterior lamina simple, more or less spatulate, with evenly rounded external margin and slightly concave inferior margin. Viewed from the side, seen to be considerably thicker above than below. Posterior lamina irregularly quadrate, with even outer and inner margins which below slightly converge; the inner margin distally produced into a conspicuous rounded, noduliform process, which projects slightly below the level of the concave inferior margin of the anterior lamina, and is consequently visible when the copulatory apparatus in its entirety is viewed from the front. Above and externally, the interspace between the anterior and posterior laminæ is occupied by a small sclerite, with even margins and rounded below, which, dilating above, forms the posterior margin of the superior aperture of the sheath, of which the walls are composed of the four laminæ just described, and which contains the protrusible portion of the copulatory apparatus. This protrusible portion is articulated at its proximal end to a simple rod, which is itself articulated to the upper extremity of the anterior lamina. Protrusible portion curved almost through the arc of a semicircle, and composed of two segments. The distal segment about twice as long as the proximal, membranous and hollow behind, chitinous in front, with its posterior portion armed with a simple small process.

A dozen specimens found under stones in the Banana plantations at the base of the Peak.

In many points this species appears to resemble *Sp. paraensis* (Humb. & Sauss.). But the absence of all knowledge of the form of the copulatory apparatus of that species makes it impossible for me to refer these specimens to it.

INSECTA, excepting Coleoptera.

By W. F. Kirby, F.L.S., F.E.S.,
Assistant in the Zoological Department, British Museum.

Notwithstanding the comparatively large proportion of new species in the present collection, it would be a mistake to suppose that very many will ultimately prove to be confined to the island of Fernando Noronha. The greater part belong to Orders of insects which are comparatively little collected or studied, and among which large numbers of conspicuous species remain to be described, even from the best explored tropical countries.

The few Lepidoptera in the collection were taken at an unfavourable season of the year, and many are worn specimens. They exhibit more decidedly West-Indian affinities than might have been expected.

I prefix to the paper a full list of all the species obtained, except a few which were worn, immature, or too scantily represented for satisfactory identification. They are arranged systematically under the orders and principal families to which they belong.

List of Species obtained.

Order **ORTHOPTERA.**

Forficulidæ.

1. Pygidicrana notigera, *Stål.*
2. Labidura riparia, *Pall.*
3. Anisolabis janeirensis, *Dohrn.*
4. —— Antoni, *Dohrn.*

Blattidæ.

5. Phyllodromia poststriga, *Walk.*
6. Ischnoptera lucida, *Walk.*
7. Periplaneta americana, *Linn.*
8. Blatta incommoda, n. sp.
9. Leucophæa surinamensis, *Linn.*
10. Euthyrrapha pacifica, *Coq.*

Gryllidæ.

11. Scapteriscus abbreviatus, *Scudd.*
12. Gryllus assimilis, *Fabr.*
13. —— forticeps, *Sauss.*
14. Œcanthus (?) pallidocinctus, n. sp.

Phanopteridæ.

15. Conocephalus vernalis, n. sp.
    —— ——, var. n. frater.
16. Œcella (n. g.) furcifera, n. sp.
17. Meroncidius viridinervis, n. sp.

Locustidæ.

18. Stenopola dorsalis, *Thunb.*

Order **NEUROPTERA.**

ODONATA.

LIBELLULIDÆ.

19. Pantala flavescens, *Fabr.*
20. Tramea basalis, *Burm.*

Order **HYMENOPTERA.**

TEREBRANTIA.

ENTOMOPHAGA.

CHALCIDIDÆ.

21. Blastophaga obscura, n. sp.
22. Ganosoma dispar, n. sp.

EVANIIDÆ.

23. Evania lævigata, *Latr.*

ACULEATA.

HETEROGYNA.

FORMICIDÆ.

24. Camponotus bimaculatus, *Smith.*
25. Pheidole omnivora, n. sp.

FOSSORES.

BEMBICIDÆ.

26. Monedula signata, *Linn.*

POMPILIDÆ.

27. Pompilus nesophilus, n. sp.

LARRIDÆ.

28. Tachytes inconspicuus, n. sp.

DIPLOPTERA.

VESPIDÆ.

29. Polistes Ridleyi, n. sp.

ANTHOPHILA.

ANDRENIDÆ.

30. Halictus lævipyga, n. sp.
31. —— alternipes, n. sp.
32. —— atripyga, n. sp.

Order **LEPIDOPTERA.**

RHOPALOCERA.

LYCÆNIDÆ.

33. Tarucus Hanno, *Stoll.*

HETEROCERA.

NOCTUÆ.

34. Heliothis armiger, *Hübn.*
35. Anomis (?) dispartita, *Walk.*
36. Anthophila flammicincta, *Walk.*
37. Bolina bivittata, *Walk.*
38. Thermesia gemmatalis, *Hübn.*

GEOMETRES.

39. Nemoria denticularia, *Walk.*
40. Acidalia Fara, n. sp.

PYRALES.

41. Pyralis manihotalis, *Guén.*
42. Samea castellalis, *Guén.*
43. Hymenia perspectalis, *Hübn.*
44. Phakellura hyalinata, *Linn.*
45. Margaronia jairusalis, *Walk.*
46. Acharana phæopteralis, *Guén.*
47. Pachyzancla detritalis, *Guén.*
48. Opsibotys flavidissimalis, *Grote.*

CRAMBI.

PHYCIDIDÆ.

49. Mella zinckenella, *Treitschke.*

Order HEMIPTERA.

HETEROPTERA.

PENTATOMIDÆ.

50. Pentatoma testacea, *Dall.*

LYGÆIDÆ.

51. Lygæus rufoculis, n. sp.
52. Heræus variegatus, n. sp.
53. Ligyrocoris balteatus, *Stål.*
54. —— bipunctatus, n. sp.

VELIIDÆ.

55. Rhagovelia incerta, n. sp.

Order DIPTERA.

DOLICHOPODIDÆ.

56. Psilopus metallifer, *Walk.*

SYRPHIDÆ.

57. Temnocera vesiculosa, *Fabr.*

MUSCIDÆ.

58. Sarcophaga calida, *Wied.*

Description of New Species and Special Notes.

1. PYGIDICRANA NOTIGERA, *Stål.*

Pygidicrana notigera, *Stål, Eugenie's Resa, Zool. Ins.* p. 299 (1858).

Flew into light.

2. LABIDURA RIPARIA (*Pall.*).

Forficula riparia, *Pall. Reise,* ii. Anhang, p. 30 (1773).

A cosmopolitan species.

3. ANISOLABIS JANEIRENSIS (*Dohrn*).

Forcinella janeirensis, *Dohrn, Stett. ent. Zeit.* xxv. p. 285.

4. ANISOLABIS ANTONI (*Dohrn*).

Forcinella Antoni, *Dohrn, Stett. ent. Zeit.* xxv. p. 289 (1864).

These earwigs were common under stones in the main island.

5. PHYLLODROMIA POSTSTRIGA (*Walk.*).

Blatta poststriga, *Walk. Cat. Blatt.* p. 99, n. 69 (1868).

The locality of the typical specimen is unknown.

6. ISCHNOPTERA LUCIDA, *Walk.*

Ischnoptera lucida, *Walk. Cat. Blatt.* p. 120, n. 39 (1868).

A single immature specimen, probably belonging to this species. Taken under stones, base of Peak.

7. PERIPLANETA AMERICANA (*Linn.*).

Blatta americana, *Linn. Syst. Nat.* i. p. 424, n. 4 (1758).

A cosmopolitan species. Common and introduced.

8. BLATTA INCOMMODA, n. sp.

Long. corp. 11½ millim.

Female. Ferruginous brown; the thorax and sides of the abdomen varied with black; legs and costal margin of the tegmina testaceous. Pronotum rather long, moderately convex, the sides converging in front, the hinder angles rounded off, and the hind border convex. Tegmina broad, covering the whole base of the abdomen, but ceasing at about two fifths of its length.

Similar to *B. orientalis*, Linn., but much smaller, the tegmina much larger, and the pronotum longer.

9. LEUCOPHÆA SURINAMENSIS (*Linn.*).

Blatta surinamensis, *Linn. Syst. Nat.* i. p. 424, n. 3 (1758).

A cosmopolitan species. Under stones, base of Peak.

10. EUTHYRRAPHA PACIFICA (*Coq.*).

Blatta pacifica, *Coqueb. Illustr. Ins.* i. p. 91, pl. xxi. f. 1 (1801).

11. SCAPTERISCUS ABBREVIATUS, *Scudd.*

Scapteriscus abbreviatus, *Scudd. Mem. Peabody Acad. Sci.* i. p. 14, t. i. ff. 8, 20 (1869).

Larvæ found in burrows in the sand under a *Conferva* (*Enteromorpha*), in salt water, on the shore of San Antonio Bay, a little above high water. Perfect insect in and about the yards of the house.

12. GRYLLUS ASSIMILIS (*Fabr.*).

Acheta assimilis, *Fabr. Syst. Ent.* p. 280, n. 3 (1775).

A species widely distributed in America. This is the black cricket mentioned by Webster and other visitors to the island. It is very common in the central district on the paths, and makes a great noise, especially about 4 o'clock in the afternoon.

13. GRYLLUS FORTICEPS, *Sauss.*

Gryllus forticeps, *Sauss. Miss. Sci. Mex.* vi. p. 407 (1870).

14. ŒCANTHUS (?) PALLIDOCINCTUS, n. sp.

Long. corp. 13 millim.

Male. Reddish brown, abdomen, hind knees, and hind tarsi darker; head rather flattened, the palpi and the outside of the scape of the long and slender antennæ towards the base whitish. Pronotum longer than broad, sides subparallel, more shining and paler on the lower lateral border than above; elytra brown, reticulated with darker nervures, about two fifths as long as the abdomen, which is rather long and cylindrical, the incisions conspicuously pale; cerci broken, but the remaining portions are bordered on each side with very long and fine hairs. Legs short and stout, and slightly compressed; all the femora enlarged, the middle ones least so; hind tibiæ spined from the base, with 3 large terminal spines on each side, and 3 or 4 larger spines alternating with smaller ones beyond the middle; first joint of tarsi with 2 small and 1 large spine on each side.

Probably belongs to a new genus of *Œcanthidæ*, but has a superficial resemblance to *Gryllodes*.

15. CONOCEPHALUS VERNALIS, n. sp.

Exp. al. circa 78 millim.

Bright grass-green; wings hyaline, with bright green nervures; fastigium short, obtusely rounded, as in *C. triops*, Linn.; four front femora unarmed. Male with face, antennæ, eyes, and the whole of the fastigium whitish; tips of mandibles and palpi red; tibiæ paler than the ground-colour; auditory apparatus and tarsi beneath blackish; tegmina yellowish along the costa, a buff streak at the base above the subcostal nervure, and a white basal streak on the left side above the median nervure. Female much less varied with white; labrum white, mandibles more yellowish, auditory apparatus and tarsi whitish, the latter brown below; ovipositor a little longer than the abdomen, extending far beyond the knees, but shorter than the closed wings; ovipositor paler towards the extremity, and slightly veined with reddish, the extreme tips of the blades black.

This grasshopper was very common everywhere in the Main and Rat Island. It makes a great noise at night. The brown form, which flew about with it, was not so common.

Var. FRATER.

Exp. al. 75–83 millim.

Brown; the thorax apparently rather longer and narrower, an effect which is caused by an indistinct pale or blackish line on each side; frequently a pale streak behind each eye; mandibles varied with pale reddish, the extreme tips black; tegmina greyish brown, often with dark speckles above and below the principal nervures and on the costa beyond the middle (similar speckles are visible on one of the green specimens); wings hyaline, with greyish-brown nervures.

Genus Œcella, n. gen.

Affinities doubtful; nearest to *Bargilis* in the structure of the legs, but more nearly approaching *Elimæa* in neuration.

Vertex slightly convex, shaped nearly like an equilateral triangle when viewed from above, the fastigium projecting about as far as the scapes of the antennæ, when the latter are recurved. Eyes large, round, prominent. Antennæ slender, filiform, at least as long as the tegmina. Pronotum above flat, oblong, slightly narrowed in front and rounded behind, excised laterally at the base of the wings. Tegmina rather narrow, especially at the tips, but hardly pointed; shorter than the wings, the drums of the male triangular, vitreous, nearly alike on both tegmina. Front legs moderately stout, unarmed; the tibiæ much swollen at the base to receive the linear foramina, which are well marked on both sides. Tarsi of all the legs similar, of nearly equal size, and about as long as broad, the second joint lobate, the last very slender, and nearly as long as the two preceding joints together. Middle tibiæ with a few very short and small spines towards the extremity. Hind legs long and slender, the basal half of the femora moderately thickened, furrowed on the side, and carinated below; tibiæ with a double row of short and slender spines, and with two small spines at the tip. Cerci of the male nearly as long as the short abdomen, with long terminal forks, the longest slender and almost sickle-shaped at the tip; subgenital laminæ short, concave at the extremity. Ovipositor nearly as long as the abdomen, moderately broad, strongly compressed, turned upwards, and pointed at the tip.

16. Œcella furcifera, n. sp.

Exp. tegm. 38 millim.; exp. al. 42 millim.

Head, thorax, tegmina, tips and veins of wings, and greater part of legs grass-green; antennæ and tibiæ, abdomen and appendages yellowish, a yellowish line on each side of the pronotum above; wings hyaline.

Hab. Pernambuco and Fernando Noronha. In all the specimens from the latter locality the green colour has more or less faded to yellowish brown. When fresh this insect is bright green. It was common on Main Island, and especially on Rat Island.

17. **Meroncidius viridinervis**, n. sp.

Exp. al. 65 millim.; long. corp. 38 millim.

Male. Brown, head smooth; labrum greenish; mandibles black, except at the base; a depressed circle surrounding the space of the antennæ, and the fastigium projecting in a spoon-shape between them; scape pointed; flagellum broken: the basal joints varied with lighter and darker brown; thorax strongly granulated, a little speckled with black, and much raised behind, where it assumes a slight greenish tint; tegmina brown, minutely reticulated and spotted with dark brown, chiefly above and below the nervures; longitudinal nervures mostly green; in the costal area the nervures are blackish towards the base, where they anastomose a little; on the disk the transverse nervures are brown or indistinctly green; inner margin with alternate darker and paler spaces: wings smoky hyaline, with reddish-brown longitudinal and brown transverse nervures; hind margins damaged, but probably browner than the rest of the wing; legs indistinctly mottled; spines of femora mostly black on the inner sides, hind femora with a black basal streak on the outside.

Somewhat resembles *M. indistinctus*, Walk., but the wings are shorter.

A single specimen on a tree in the Sapate.

18. **Stenopola dorsalis** (*Thunb.*).

Truxalis dorsalis, *Thunb. Nov. Acta Upsal.* ix. p. 80 (1827).
Stenopola dorsalis, *Stål, Recensio Orth.* i. p. 83 (1873).

The hind legs have not been described; they are reddish brown, the middle of the femora being black on both surfaces, the striations more or less marked with paler. The hind tibiæ are armed, except on the basal third, with a double row of moderately long and pointed spines, the intermediate space above is clothed with long fine white hairs, and there is a row of much shorter white hairs on the under surface also. The sides and under surface of the hind tibiæ are generally dark green or blackish; at the tip there are two short spines on the outside, and two long ones on the inside. There are apparently only three joints to the hind tarsi: the first is three times as long as broad, but is broad and flattened; the second is much narrower, half as long again as broad, and produced into a long tooth at the extremity beneath, and the terminal joint is very slender at the base, gradually enlarging to the pulvillus, and about as long as the two preceding joints together.

The species appears to be common, and differs considerably in size, the tegmina expanding from 30–40 millim., and the body measuring from 18–20 millim. in length.

On both Main and Rat islands, but especially common on the latter.

19. PANTALA FLAVESCENS (*Fabr.*).

Libellula flavescens, *Fabr. Ent. Syst. Suppl.* p. 285 (1798).

Distribution. World-wide.

Very common everywhere on Main Island. The larvæ living in puddles in the central district.

20. TRAMEA BASALIS (*Burm.*).

Libellula basalis, *Burm. Handb. Ent.* ii. p. 852, n. 25 (1839).

Less common than the preceding. The abdomen when fresh is dark crimson-red. A well-known South-American species.

21. BLASTOPHAGA OBSCURA, n. sp.

Male. Long. corp. 2 millim.

Brown or yellowish brown, smooth, except a few short hairs on the tarsi. Front tarsi apparently 3-jointed, middle and hind tarsi 5-jointed; tarsal claws very strong, and front and hind tibiæ ending in short strong spines.

This species resembles the description of *B. brasiliensis*, Mayr, from Blumenau, but is considerably larger. I think it useless to give a detailed description, for which a larger series, including both sexes, and preserved in different ways, would be desirable. The locality will probably serve to fix the species, especially as true *Blastophaga* does not appear to be well represented in America.

22. GANOSOMA DISPAR, n. sp.

Male. Long. corp. 1½ millim.

Yellow, smooth; head forming a long oval, broad behind, gradually narrowed in front, antennæ inserted widely apart; legs of nearly equal size and structure, femora slightly thickened; tibiæ spinose on the outer edge, and terminating in a coronet of short spines, none of which are conspicuously longer than the rest; first joint of the tarsi longer than thick; abdomen long, tapering.

Differs from *Ganosoma attenuatum*, Mayr (♂), in not being depressed, and (perhaps) in the long abdomen; and from *Tetragonaspis gracilicornis*, Mayr (♀), in the much shorter joints of the antennæ.

Female. Long. corp. 2 millim.; ovipositor 4½ millim.

Tawny-yellow, with a slight greenish-coppery reflexion (colours perhaps altered by spirit); antennæ 12-jointed, serrated and set with very short hairs; brown, except the two basal joints; scape as long as the three following joints, second joint rather longer than the fourth, third (annulus) very small, fifth and following gradually smaller, the last three joints forming a club; ovipositor more than twice as long as the body; veins of the wings of nearly uniform thickness; ulna as long as the pterostigma, hardly curved or thickened, metacarpus about as long as the radius. Head and thorax finely rugose. Legs yellow, the femora slightly thickened.

Appears to approach most nearly *Tetragonaspis* * *flavicollis*, Mayr, but that species has two annuli (ring-joints) to the antennæ. Except in the structure of the antennæ, the single specimen before me much resembles the figure of *T. gracilicornis*, Mayr, but the latter species has longer hairs on the antennæ, and the terminal joints do not form a club, to say nothing of other differences.

23. EVANIA LÆVIGATA, *Latr.*

Evania lævigata, *Latr. Gen. Crust. Ins.* iii. p. 251 (1807).

A cosmopolitan species. The larvæ of this genus are parasitic in the egg-capsules of Blattidæ.

A single specimen taken in a house at Sambaquichaba. It is very common in Pernambuco.

24. CAMPONOTUS BIMACULATUS (*Smith*).

Formica bimaculata, *Smith, Cat. Hym. B. M.* vi. p. 50, n. 171 (1858).

Six specimens, all small workers. The species is new to the Museum collection. Smith described it from St. Vincent's. Roger (Berl. ent. Zeitschr. vi. p. 285, 1862) identifies this species with *Formica ruficeps*, Fabr. (Syst. Piez. p. 404, n. 32); but I am not satisfied that this is correct, as Fabricius does not mention the conspicuous pale spots on the second segment of the abdomen. In the small workers the head is mostly black;

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* This genus proved to be the female of *Ganosoma*.

in the large workers it is red. Dr. Mayr records this species from New Granada, and it is probably widely distributed in South America.

Under the wood of a Burra tree in the Sapate.

25. PHEIDOLE OMNIVORA, n. sp.

Soldier 4½ millim.; worker 2½–3 millim. in length.

Soldier red, shining (abdomen darker), sparingly covered with raised white hairs. Head, without the mandibles, about as broad as long, finely and sparingly longitudinally striated above and in the middle, where it is depressed, behind; sides gradually rounded behind the eyes. Mandibles very broad, hardly punctured, blackish at the base and tips. Scape of the antennæ straight, gradually thickened beyond the middle, nearly one third of the length of the antennæ. Second joint about three times as long as broad, joints 3–9 very slightly longer than broad, joint 10 much thicker and twice as long as broad, joint 11 rather shorter and thicker, and joint 12 forming a long pointed cone; the hair on the antennæ is thicker and closer than on any other part of the body. Mesonotum with a hump on each side above, and finely punctured above; metanotum, which is armed with two strong spines, more closely; first node of the petiole with the spine somewhat truncated at the extremity; second node fully twice as broad as the first, and with strongly projecting lateral angles; abdomen finely punctured at the base.

Worker similar, but smaller and generally darker, the antennæ lighter; the scape nearly as long as the remainder of the antennæ, slightly curved, but hardly thickened, and the terminal joint thicker in proportion and less pointed than in the soldier. The spines on the metanotum and on the first node of the petiole are much shorter, and the projecting sides of the second node are rounded off.

This species much resembles *Pheidole pusilla*, Heer, in size and general appearance, but differs widely in structure.

This was exceedingly abundant in the houses, making nests in the earth between the bricks of the floor. It is very destructive. devouring all kinds of food, and even ate up the insects we captured, in the chip-boxes.

26. MONEDULA SIGNATA (*Linn.*).

Vespa signata, *Linn. Syst Nat.* ed. x. i. p. 574, n. 14 (1758).

A common South-American species.

Very common on the sand-hills, where it makes its burrow.

27. POMPILUS NESOPHILUS, n. sp.

Long. corp. 10 millim.; exp. al. 15 millim.

Female. Dull black, first three segments of abdomen, the sides of the fourth, and the under surface of the hind tibiæ red. Wings smoky, a little lighter and subhyaline on the hind wings and towards the base of the fore wings.

Head large, eyes hardly extending to the base of the jaws, face rather more strongly punctured than the vertex; clypeus short, slightly emarginate; labrum short, transverse; eyes nearly parallel, front ocellus forming the apex of a rectangle with the hinder ocelli, the two latter rather wider apart than the space between these ocelli and the eyes; second joint of the antennæ half as long again as the third. Pronotum falling in front to the neck in a short rounded curve, rather broader than the meso- or metanotum; the metanotum is furnished with a small prominence on each side near the base.

Second and third cubital cells of nearly equal size, the second recurrent nervure striking the third cubital cell in the middle.

Spines of the legs as usual.

Much resembles *P. sobrinus*, Blanch., a Chilian species, in which, however, the thorax is verdigris-green above, instead of black.

Taken flying over paths in the centre of the island, not common and difficult to catch.

28. TACHYTES INCONSPICUUS, n. sp.

Long. corp. 6–8 millim.

Black, clothed with a very fine silvery pile (that on the upper part of the face with a slight golden appearance in certain lights), otherwise most conspicuous on the sides of the abdomen, towards the extremities of the segments; thorax and scutellum shining, with very numerous small punctures, not very close together: metathorax rugosely-punctate; tegulæ testaceous; wings clear hyaline, with a strong violet iridescence; nervures dark brown.

Closely allied to *T. iridipennis*, Smith, from Ega, but in that species the thorax is longitudinally striated, and the tips of the tarsi are ferruginous.

29. Polistes Ridleyi, n. sp.

Long. corp. 15–16 millim.; exp. al. 26–20 millim.

Worker. Varied with ferruginous red, dark brown, black, and yellow; clothed with very fine silky pubescence. Head red, the vertex darker, the face and orbits lighter, base of the head black; antennæ black in the middle above. Thorax black, the prothorax and mesothorax red above, the hinder edge of the prothorax paler, and the front edge narrowly bordered with yellow; the edges and central line of the mesothorax more or less bordered with black above; on the pleura, beneath the fore wings, is a conspicuous yellow spot; scutellum and postscutellum edged in front with yellow, the band on the former hardly complete in the middle, and the space behind it more or less red; metathorax finely and transversely striated, a deep longitudinal channel in the middle, more strongly striated, and edged with a yellow stripe on each side; on each side, above the base of the hind coxæ, is another yellow spot. Abdomen dark brown, finely pubescent, shading into black at the base, and generally more or less red at the extremity. Legs red, coxæ and femora black, knees red or yellow, hind tibiæ more or less black in the middle. Wings smoky hyaline, strongly tinged with ferruginous along the costa of the fore wings; tegulæ ferruginous.

Var. *a.* Face, head beneath, pectus, and coxæ beneath yellow; femora striped beneath with yellow; first two segments of the abdomen with a small yellow spot on each side above, and a larger one near the base of the first segment beneath.

Very nearly allied to *P. instabilis*, Sauss., from Mexico; but this is a redder insect, with the segments of the abdomen always more or less bordered with yellow.

This insect is called here "*Marimboudo*," and is very common. It makes its nest on the underside of an overhanging rock or eaves of a house, or on the branch of a tree. I have seen a Cashew-nut tree containing an immense number of nests in various stages of construction. The nest consists of a single comb of cells of a triangular or oval outline, and attached by a pedicel at the narrow end; a large one is about four inches in length, and three across in the broadest part. The cells are about three quarters of an inch deep, and a quarter of an inch across. The insect stings slightly, but only when much irritated.

It plays a very important part in the fertilization of the flowers, especially the Cucurbitaceæ.

30. HALICTUS LÆVIPYGA, n. sp.

Female. Long. corp. 10 millim.; exp. al. 16 millim.

Head and thorax dark green, slightly bronzed; abdomen shining, shading into violet at the extremity of the segments; wings hyaline; legs black, clothed with pale hairs.

Head and face finely and closely punctured, sparingly studded with whitish hairs, dark green, occasionally shading into bronzy or violet in certain lights; clypeus green or violet-black, with much larger and fewer punctures than the upper part of the head; the extremity and the labrum black, the lower mouth-parts dull bronzy green; antennæ black, ferruginous towards the extremity beneath; thorax dark green, thickly punctured, most finely on the prothorax, which shades into bronzy; metanotum and base of abdomen above densely clothed with whitish hairs; metanotum with longitudinally diverging striæ in front, behind deeply and longitudinally concave, with small punctures, the intermediate spaces still more finely punctured; tegulæ testaceous; wings hyaline, with brown nervures and a slight violet iridescence; pectus dull green, densely clothed with whitish hairs; propectus violet-black; legs black, with whitish hairs above, and the tibiæ and tarsi densely clothed with red hairs beneath; the knees (very narrowly), spines, and last joint of the tarsi mostly reddish. Abdomen smooth and shining, the punctuation being extremely fine, even under the microscope, and densely clothed with short white hairs, except towards the extremity of the first two segments; the segments greenish in front and violet-black behind; towards the extremity the lateral bristles are longer; under surface of abdomen brown, the extremities of the segments slightly reddish.

31. HALICTUS ALTERNIPES, n. sp.

♂ ♀. Long. corp. 11 millim.; exp. al. 13–14 millim.

Head and thorax dark green above; abdomen green, smooth and shining, the neighbourhood of the incisions more or less violet; wings hyaline, or slightly clouded in and below the radial cell, and towards the extremity of the discoidal cell of the hind wings; legs reddish, the femora and tibiæ in the middle, and often the last joint of the tarsi dark green or blackish; clypeus tipped with tawny, and with more numerous punctures than in *H. lævipyga*; the punctures of the mesothorax and the lower part of the metathorax larger; the channel of the metathorax narrower; antennæ black above, ferruginous below; cheeks bronzed.

Closely allied to *H. lævipyga*, but differs in colour and punctuation. Appears to be a very common species.

32. HALICTUS ATRIPYGA, n. sp.

♂ ♀. Long. corp. 5 millim.

Head and thorax clothed with whitish hairs, green, very finely punctured; head much bronzed; clypeus rather short, the tip black; metanotum longitudinally striated in front; abdomen bronzy black, more violet in the incisions; antennæ black, ferruginous beneath; head and thorax dull bronzy green beneath; abdomen beneath shading more into ferruginous brown; wings hyaline, with brown nervures; tegulæ pitchy; legs ferruginous, the femora, and sometimes more or less of the tibiæ, blackish.

A small species, not closely allied to any other, and easily recognizable by the strong bronzy colouring of the back of the head.

These *Halicti* were taken in the flowers of the Melons and the *Oxalis*, and play an important part in the fertilization of the flowers in the island.

33. TARUCUS HANNO, *Stoll.*

Papilio Hanno, *Stoll, Suppl. Cram.* pl. xxxix. ff. 2, 2 B (1790).

Rusticus adolescens Hanno, *Hübn. Samml. ex. Schmett.* i.

Many specimens, taken between July 25 and August 31.

The Brazilian form of this widely distributed and variable species. It is generally larger than the more northern form of the species, and stands in the British-Museum collection under the MS. name of *T. monops*, Zell. The specimens expand from 17½ to 23 millim.

This little Blue was very common on Rat and Main islands. The *Catachrysops trifracta*, Butl., said to have been caught on Rat Island by the 'Challenger' Expedition, we did not meet with; and it seems possible that there was some mistake in the labelling of this specimen, as the genus is only known from the East Indies.

34. HELIOTHIS ARMIGER (*Hübn.*).

Noctua armigera, *Hübn. Eur. Schmett., Noct.* f. 370.

A cosmopolitan species.

A single specimen was caught flying in the daytime on East Hills.

35. ANOMIS (?) DISPARTITA, *Walk.*

Anomis (?) dispartita, *Walk. Cat. Lep. Het.* xiii. p. 990, n. 8 (1857).

Described by Walker from Jamaica and St. Domingo; the specimens from Fernando Noronha most nearly resemble that obtained in the former locality.

Taken on the wing at night. Main Island.

36. ANTHOPHILA FLAMMICINCTA, *Walk.*

Anthophila flammicincta, *Walk. Cat. Lep. Het.* xxxii. p. 801 (1865).

The types are from St. Domingo.

37. BOLINA BIVITTATA, *Walk.*

Bolina bivittata, *Walk. Cat. Lep. Het.* xiii. p. 1156, n. 23 (1857).

A common species. The specimens in the British Museum are from Honduras, Venezuela, St. Domingo, and Jamaica. The single specimen from Fernando Noronha has a narrower band than any of the others; but it would require a series to show whether this character is constant in the locality, or a mere individual variation.

38. THERMESIA GEMMATALIS (*Hübn.*).

Antisarsia gemmatalis, *Hübn. Zutr. ex. Schmett*, i. p. 26, n. 77, ff. 153, 154 (1818).

Common among the wild beans on Main and Rat Islands (August 17–25).

39. NEMORIA DENTICULARIA, *Walk.*

Nemoria (?) denticularia, *Walk. Cat. Lep. Het.* xxii. p. 536, n. 20 (1861).

The locality of the type specimen is unknown; but it is probably a wide-ranging species, as there are specimens in the British Museum from Corrientes and Goya.

40. ACIDALIA FARA, n. sp.

Exp. al. 16 millim.

Male. Grey, thickly dusted with brown, the first line commencing at about one third of the length of the wing with a dark shade curving to a conspicuous black spot, thence curving sharply inwardly till it terminates in a more conspicuous dark acute angle projecting outwardly just above the inner margin; it is not continued on the hind wings. The second line commences at two thirds of the length of the wing in another dark shade on the costa, which runs obliquely to another black spot, below which it is continued in grey festoons across both pairs of wings, forming more than a half-circle on the basal side of a conspicuous black spot on the hind wings. The third line is the most conspicuous, and is formed of a series of black spots connected by a grey line on the fore wings, which curves inwards twice, a little above the middle, and again above the inner margin. On the hind wings it forms a nearly continuous black line, curving outwards at one fourth of the distance from the costa, and again, in a wider and more regular curve, below the middle. At the base of the fringes runs a row of black dashes, and between these and the third line are a series of indistinct greyish markings. Underside grey-white, with the central spots indicated, but not conspicuous. Head black above; body and legs grey; abdomen rather indistinctly banded with black above, and with a blackish space at the base of the anal tuft; femora tawny beneath, front femora and tibiæ blackish above; antennæ tawny, alternating with whitish above.

Allied to *A. retractaria* from Florida, but darker and more distinctly marked.

41. PYRALIS MANIHOTALIS, *Guén.*

Pyralis manihotalis, *Guén. Spéc. Gén. et Lép., Delt. et Pyr.* p. 121 (1854).

Described by Guénée from Cayenne.

42. SAMEA CASTELLALIS, *Guén.*

Samea castellalis, *Guén. Spéc. Gén. Lép., Delt. et Pyral.* p. 195 (1854).

A widely distributed species throughout America.

43. HYMENIA PERSPECTALIS (*Hübn.*).

Pyralis perspectalis, *Hübn. Eur. Schmett., Pyr.* f. 101.

A widely-distributed species.

44. PHAKELLURA HYALINATA (*Linn.*).

Phalæna-Geometra hyalinata, *Linn. Syst. Nat.* i. (2) p. 874, n. 279 (1767).

This little moth was very common on the Main Island, especially about the Peak, among the wild melons, &c. (August 17–20).

A cosmopolitan species.

45. MARGARONIA JAIRUSALIS, *Walk.*

Margaronia jairusalis, *Walk. Cat. Lep. Het.* xviii. p. 524, n. 15 (1859).

Originally described from Venezuela.

46. ACHARANA PHÆOPTERALIS (*Guén.*).

Botys phæopteralis, *Guén. Spéc. Gén. Lép., Delt. et Pyr.* p. 349 (1854).

A common and widely-distributed species in Tropical America.

47. PACHYZANCLA DETRITALIS (*Guén.*).

Botys detritalis, *Guén. Spéc.Gén. Lép., Delt. & Pyr.* p. 347 (1854).

Widely distributed in South America.

48. OPSIBOTYS FLAVIDISSIMALIS (*Grote*).

Botis flavidissimalis, *Grote, Canad. Ent.* ix. p. 105 (1877).

Described by Grote from Texas; but there are also specimens from South America in the British Museum.

49. MELLA ZINCKENELLA (*Treitschke*).

Phycis zinckenella, *Treitschke, Schmett. Eur.* ix. (1) p. 201 (1832).

Many specimens. A cosmopolitan species. There are specimens in the British Museum from S. Europe, S. Africa, and Australia. It is a somewhat variable insect, but is easily recognized by the broad pale costa and the huge palpi.

50. PENTATOMA TESTACEA, *Dall.*

Pentatoma testacea, *Dall. Cat. Hem.* p. 250, n. 43 (1851).

Several specimens were met with in various spots in the Main and Rat Islands.

51. LYGÆUS RUFOCULIS, n. sp.

Long. corp. 9–11 millim

Bright red, including the eyes and ocelli; head above, between and in front of ocelli, blackish; antennæ and legs blackish and setose; coxæ reddish at base, corium more or less varied with blackish, outer edge narrowly black, membrane brown, blackish in ♀. Head and thorax rugose, the former truncate and bicarinate in front. Rostrum black, extending to the extremity of the posterior coxæ. Corium fully developed in ♂; in ♀ about half as long as the abdomen, and rather pointed.

An extremely common species, allied to *L. anticus*, Walk., in which, however, the head and thorax are unicolorous red, and the tegmina are reddish brown.

This highly-coloured Bug occurred in large numbers upon the ground in the Sapate under bushes of *Jacquinia*; but was local, only found in a few spots.

52. HERÆUS VARIEGATUS, n. sp.

Long. corp. 7 millim.

Head and front of pronotum dull red; posterior lobe of pronotum testaceous, with very large separated punctures. Corium blackish, with rows of punctures; outer edge of corium testaceous, with two black spots, one at its extremity, the other a little before; the veins, a large triangular spot on the inside, and three smaller spots between this and the margins are also testaceous; scutellum with a converging testaceous line on each side; membrane blackish, with a testaceous blotch at base and tip. Antennæ finely pubescent, the two basal joints testaceous, the third blackish, the fourth black, with the base white. Legs testaceous, front and hind femora and all the tibiæ strongly spined. Body red beneath, pectus darker. Rostrum testaceous, extending to the base of the hind coxæ.

Allied to *H. percultus*, Dist.

Taken at light.

53. LIGYROCORIS BALTEATUS, *Stål.*

Ligyrocoris balteatus, *Stål, Vet.-Akad. Handl.* (2) xii. p. 146, no. 4 (1874).

Flew into light.

54. LIGYROCORIS BIPUNCTATUS, n. sp.

Long. corp. 4 millim.

Head, pronotum, and scutellum black; hinder lobe of pronotum with two short, reddish, longitudinal stripes in the middle, a reddish spot on each side in front and one at each angle behind; antennæ testaceous, the last joint black. Corium testaceous, with rows of black depressed punctures in the middle; the veins on the inner edge black, running into a large irregular apical black border; the outermost vein broadens out just before reaching it and encloses a very conspicuous oval white spot; membrane greenish, with two brown, diverging, curving lines in the middle, two brown spots at the base, and one on each side of the curve. Under surface of the body apparently black; legs testaceous, femora more or less black; but the specimen is carded in such a manner as not to allow of a proper examination of the under surface or of the legs and rostrum.

55. Rhagovelia incerta, n. sp.

Long. corp. 2½ millim., lat. 1 millim.

Blackish brown; the orbits, front of prothorax, whitish, slightly tawny; abdomen with a whitish pile on the sides and less conspicuous beneath; base of antennæ, femora above, and legs beneath tawny; closed hemilytra whitish (or slightly tawny) at the base between the nervures, but with no other pale markings except the conspicuous long-oval white spot before the tip.

A shorter and broader species than any at present represented in the British Museum; but with most general resemblance to *Microvelia vagans*, White. It is possibly a variety of the widely distributed and variable *Velia collaris*, Burm.

On grasses in the lake.

56. Psilopus metallifer, *Walk.*

Psilopus metallifer, *Walk. List Dipt. B. M.* iii. p. 647 (1849).

Flying over Cucurbitaceæ on the Peak.

57. Temnocera vesiculosa (*Fabr.*).

Syrphus vesiculosus, *Fabr. Syst. Antl.* p. 226, n. 11 (1805).

Flying over herbage in the sun, and also taken on the flowers of the cabbage in the garden.

58. Sarcophaga calida, *Wiedem.*

Sarcophaga calida, *Wiedem. Aussereurop. zweifl. Ins.* ii. p. 366, n. 24 (1830); *Walk. Ins. Saund. Dipt.* p. 326 (1856).

COLEOPTERA.

By Chas. O. Waterhouse, F.E.S.,

Assistant in the Zoological Department, British Museum.

The number of species obtained was 24. As might naturally be expected, many of them are Brazilian species or are species with a wide geographical range. One of the Heteromerous genera, which I have named *Æsthetus*, is almost certainly indigenous. Perhaps the most interesting species is a Longicorn of the genus *Acanthoderes*. At first sight I took it to be a pale variety of *A. jaspidea*, a common Brazilian species, but on closer examination the apex of the elytra was found to be different. If this species should hereafter prove to be peculiar to the island, it will be a somewhat remarkable fact.

A few of the species the determination of which would have been attended with great labour, I have left unnamed, as I feel sure they are introduced species.

BRACHELYTRA.

BELONUCHUS, sp.

A single specimen, closely resembling *B. formosus*, Grav., of Brazil, but smaller, 2¼ lines in length. It was found in a decomposing rat.

TROGOPHLŒUS, sp.

A single example, closely resembling *T. pusillus*, Grav., of Europe, but a trifle larger, with the two basal impressions of the thorax strongly marked.

NECROPHAGA.

DERMESTES FELINUS, *Fabr.*

A widely-distributed species.

EPURÆA?

A single specimen of a very small species (1¾ millim.) somewhat resembling *Epuræa limbata*, but a little narrower, with the margins not expanded, light brown, finely pubescent, closely and very finely punctured; each elytron having two fine, widely separated, impressed striæ. Abdomen covered by the elytra.

PALPICORNIA.

PHILHYDRUS MARGINELLUS, *Fabr.*

A widely-distributed species.

DACTYLOSTERNUM ABDOMINALE, *Fabr.*

A widely distributed species.

LAMELLICORNIA.

ATÆNIUS, sp.

Three examples belonging to two species. No doubt introduced.

STRATEGUS ANTÆUS, *Fabr.*

The prothorax and elytra of this North and Central-American species. [Its larvæ were found under rubbish in the Sapate with the fragments of the perfect insect, which we did not succeed in taking alive.—H. N. R.]

SERRICORNIA.

HYPORRHAGUS MARGINATUS, *Fabr.*

A single example of this West-Indian species in the flowers of an acacia in the garden.

MALACODERMATA.

XYLOPERTHA, sp.

Three specimens. Probably an introduced species. Four millimetres in length; reddish yellow, shining, with the rough anterior part of the thorax brown and the apex of the elytra pitchy. The elytra finely punctured at the base, strongly punctured posteriorly; the posterior declivity also strongly punctured, with three nodes on its upper margin on each elytron.

[These came to light in our rooms.—H. N. R.]

HETEROMERA.

EPITRAGUS BATESII, *Mäklin.*

Elongatus, ellipticus, modice convexus, parum nitidus, parce flavo-pubescens, crebre punctatus; elytris striato-punctatis, striis postice obsoletis.

Long. 7½ millim.

The head is closely and rather strongly punctured. The thorax two fifths broader than long, broadest a little behind the middle, very slightly narrowed behind, a little more in front; distinctly and moderately strongly punctured; the punctures on the disk separated from each other by one or one and a half times the diameter of the punctures; the punctures towards the sides larger and closer together, giving a slight rough appearance; the punctures at the anterior margin are finer. The elytra are at the base a little wider than the base of the thorax, very slightly widened to rather behind the middle and then arcuately narrowed to the apex; moderately finely but distinctly punctured, the punctures not very close together; with several short lines of rather larger punctures, which are most distinct towards the margin. Antennæ and legs pitchy.

Numerous examples of this species from the Amazons are labelled in Mr. F. Bates's collection with the name "*E. Batesii*, Mäkl.," but the species does not appear to be described.

BLAPSTINUS RIDLEYI, n. sp.

Elongatus, oblongo-ovatus, parum nitidus, fusco-brunneus, flavo-pubescens; thorace crebre evidenter punctato; elytris punctato-striatis, interstitiis lateralibus et ad apicem convexiusculis, subtiliter vix crebre punctatis; antennis, tibiis tarsisque piceis.

Long. 5 millim.

Antennæ with the third joint elongate, about one fourth longer than the second, the fourth a trifle shorter than the third, the fifth, sixth, and seventh about as long as broad, the eighth, ninth, and tenth slightly transverse. The head is moderately strongly punctured, but the punctures are not *very* close together; the epistome is moderately emarginate, rather more closely punctured than the head. The thorax is evenly convex, broadest *at* posterior angles, scarcely sinuate at the sides, narrowed at the anterior third; moderately strongly punctured, the intervals between the punctures about equal to the diameter of the punctures; the anterior angles moderately prominent and acute; the base rather strongly bisinuate. The elytra a little broader than the thorax; somewhat strongly punctate-striate; the striæ near the suture scarcely impressed at the base; the punctures in the striæ moderately large and close together; the punctures on the interstices are fine but distinct, the spaces between them being about once and a half the diameter of the punctures.

I have ventured to describe this species as it appears to be new, although probably introduced.

BLAPSTINUS, sp.

Several specimens of a species closely resembling *B. pulverulentus*, Esch., but with the striæ of the elytra more impressed. There are several North-American species closely allied to this with which I am unacquainted, and it is not improbable that it is referable to one of them.

ÆSTHETUS, n. gen.

General characters of *Cyrtosoma*. Mentum small, narrowed at the base, truncate in front; ligula somewhat round; labial palpi short and stout, the apical joint rather large, ovate. Labrum nearly twice as broad as long, nearly straight in front, the angles rounded. Head transversely impressed between the eyes. Epistome not separated from the forehead by a distinct line, considerably advanced in front of the insertion of the antennæ, obliquely narrowed in front. Thorax evenly convex, the sides gently arcuate. Scutellum very small, short triangular. Elytra oblong-ovate, very convex, but somewhat flattened dorsally; their epipleura very broad and flat, gradually narrowed to the apex of the elytra. Wings absent. Prosternal process considerably produced posteriorly, acuminate, horizontal. Mesosternum sloping, slightly concave. Metasternum very short; intermediate and posterior coxal cavities separated by a very narrow space. Antennæ moderately long and slender, the third to seventh joints elongate, the apical joints a trifle broader. All the tibiæ slightly curved.

ÆSTHETUS TUBERCULATUS, n. sp.

Piceo-niger, nitidus; capite crebre sat fortiter punctato, epistomo convexo, subtiliter punctulato; labro piceo-flavo; thorace creberrime punctato, latera versus tenuiter ruguloso; elytris opacis, fortiter striatis, striis impunctatis, interstitiis sat convexis, singulis serie tuberculorum minutorum instructis; antennis, palpis tarsisque piceis, tibiarum apice intus, tarsisque subtus fulvo-pilosis.

Long. 9–11 millim.

The antennæ are somewhat slender; the second joint scarcely longer than broad, the third three times as long as the second; the fourth to seventh joints elongate, each a trifle shorter and broader at its apex than the previous one; the eighth, ninth, and tenth joints pilose, broader and shorter than the seventh, but not transverse; the eleventh oval. The thorax is evenly convex, very gently arcuate at the base, emarginate in front, moderately rounded at the sides, finely margined all round (except at the middle of the front margin), the posterior angles are *very* slightly projecting, the anterior angles slightly obtuse. The punctures on the disk are close and distinct, at the base and at the sides they are very fine and obscure. On each side of the disk the surface is finely longitudinally rugulose, but this is very slight in the larger examples. The interstices of the elytra are closely and very finely punctured, each interstice having a line of rather closely placed, minute, shining tubercles. Epipleura of the elytra dull. Under flanks of the prothorax dull and closely longitudinally striated. Sterna and abdomen shining, finely punctured.

The two smaller examples have the thorax relatively narrower than in the larger examples, and the rugulose surface more marked and more extended. These differences are no doubt sexual.

These were found under stones and bark in the woods of the Sapate.

COPIDITA, sp.

Several examples of a species which I am unable to determine. Yellowish, usually with slight grey shade on the elytra. Length 6–7 millim.

Those captured were attracted by a light.

BRUCHIDA.

BRUCHUS POROSUS, *Sharp*.

Two imperfect male specimens, which may be referable to *B. porosus*, Sharp (Biol. Cent.-Amer., Coleopt. v. p. 490), from Guatemala, the type of which (unique) is a female. The brown colour is rather more suffused over the elytra, and the punctures are not quite so large. The pectinations of the antennæ are very long.

RHYNCHOPHORA.

SITOPHILUS ORYZÆ, *L.*

Introduced. [It is very destructive to the maize-grains, so that in the store-rooms the maize is covered with a thick layer of sand to prevent their attacks.—*H. N. R.*]

XYLOPHAGA.

TOMICUS?

Two immature specimens belonging to this or an allied genus. Very pale yellow; 1½ millim. in length.

PYCNARTHRUM? SETULOSUM, n. sp.

Oblongo-ovatum, brunneum, sat nitidum, convexum; thorace latitudine paulo breviore, convexo, postice paulo angustiore, ante medium oblique angustato, creberrime subtiliter punctulato; elytris thoracis basi perparum latioribus, subtiliter striato-punctatis, interstitiis parce subtilius punctatis, parce pubescentibus, seriatim squamulato-setosis; antennis pedibusque sordide testaceis.

Long. 2 millim.

Head distinctly visible from above; concave in front in one sex. Eyes coarsely granular, widely separated above, but very slightly separated below. Antennæ testaceous; funiculus 6-jointed (or *possibly* 7)*; the first large, subglobose; the following joints very short and transverse, gradually increasing in width; club large, 3-jointed, oval, pubescent. The thorax has a well-defined margin separating the under flanks. The surface (seen through a microscope) is finely coriaceous, moderately finely punctured, the intervals between the punctures about equal to the diameter of the punctures; sparsely pubescent, the hairs at the front margin slightly thickened. The striæ of the elytra are lightly impressed, but scarcely so on the disk; the punctures in the striæ moderately fine and close together, the punctures on the interstices rather smaller and moderately widely separated. Anterior tibiæ rather broad, with four or five small obtuse teeth on the outer side, and two larger ones, one at one third from the apex, the other apical. Tarsi slender.

This insect agrees in the majority of its characters with *Pycnarthrum gracile*, Eichh. (Mém. Soc. R. d. Sci. Liège, viii. 1878, p. 104). The anterior tibiæ are, however, evidently different: "tibiæ anteriores apice extus rotundatæ." The structure of the antennæ appears to be the same, but the club is ovate and not acuminate. The elytra are punctate-striate and not crenate-striate, and the punctures are round and not subquadrate, &c.

It appears to be related to *Cnesinus*, Horn, but the anterior coxæ are not so widely separated.

[It was bred from the bark of the endemic fig-tree, from a specimen out of the garden of the Residency.—*H. N. R.*]

PLATYPUS PARALLELUS, *F.*

Two examples of this Brazilian species.

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* The joints after the first are so confused that even with the antenna mounted in balsam I am not quite certain of their number.

LONGICORNIA.

ACANTHODERES RIDLEYI, n. sp.

Latus, depressus, omnino albo-griseo-pubescens; elytris pone medium macula laterali inconspicua ornatis; apice mucro brevi instructo.

Long. 11½–16 millim.

Form and general appearance of *A. jaspicea*, Germ., but a little more depressed and with the elytra rather more obtuse at the apex. The colour is pale whitish grey, generally with some sandy-yellow shade on the base of the antennæ, disk of the thorax, and on parts of the elytra. The front of the head is paler, with some conspicuous black punctures, especially between the eyes. The thorax has the usual median raised line and slight swelling on each side of the disk; there is no black at the sides; there is a line of very distinct black punctures along the basal margin, and a similar (but less regular) line along the front margin, and there are some other punctures scattered over the surface. The elytra have the usual costa distinct, slightly sinuous as in *A. jaspidea*. On the shoulder a few small tubercles may be traced through the pubescence. Some examples have scarcely any trace of spots, but most have a not very conspicuous pale fuscous spot behind the middle near the side, and behind this there are generally numerous black punctures which are surrounded by a brown shade; usually a short oblique brown line may be seen at the apex of the costa. Apical mucro shorter and less acute than in *A. jaspidea*. Abdomen with a slight grey shade in the middle, and a line of black dots on each side. Tibiæ unicolorous, or with a very slight pale brown spot near the apex. Some examples have a slight oblique brown spot on the disk, rather before the middle.

[These flew into light in the evening, and were very plentiful. They made a loud squeaking noise when caught.—*H. N. R.*]

TRYPANIDIUS ISOLATUS, n. sp.

Dense pallide griseo-pubescens; thorace guttis minutis nonnullis ornato; elytris nigro-punctatis.

Long. 13–15 millim.

Closely allied to *T. dimidiatus*, Th., but relatively a little narrower and quite differently coloured. The pubescence is very pale grey, some parts being a trifle paler than others; and there is a slight mixture of pale yellowish-brown pubescence, especially on the elytra. On the underside the pubescence is more sandy yellow, leaving the middle of the sterna and abdomen dark. The thorax has the usual line of large punctures at the base; a very slight raised line behind the middle of the disk; the lateral tooth small and acute. The elytra have the very slight costa near the suture a little less raised at the base than in *T. dimidiatus*, and the apical truncature of each elytron is not straight but has the angles rounded. The black punctures are arranged as in *T. dimidiatus*, but extend to the apex. There is a small pale spot at the base close to the scutellum, and a scarcely noticeable brown spot near the suture a little way from the base. One example has a slight whitish mark on the suture just before the middle, and a moderately broad whitish band near the apex, somewhat similar to the band in *T. dimidiatus*, but broader nearer the apex and less angular near the suture, where it is only carried up to a level with its origin on the margin.

This species is, in many respects, intermediate between *T. dimidiatus* and *T. melancholicus*.

[These also came to light with the preceding, but were rarer, only two being taken.—*H. N. R.*]

PSEUDOTRIMERA.

SCYMNUS, sp.

Two examples of a species resembling the Indian *S. xeranipelinus*, Muls., but a trifle smaller ($1\frac{1}{2}$ millim.); uniform brownish yellow, with golden pubescence; punctuation of the elytra close, fine but distinct; metasternum very strongly punctured.

THYSANURA and COLLEMBOLA.

By H. N. RIDLEY, M.A., F.L.S.

IAPYX SAUSSURII, *Humbert, Rev. et Mag. Zool.* Sept. 1868, p. 351, pl. ii. figs. 1–5.

A single specimen of what I believe to be a young example of this little animal was obtained under a stone in the Sapate woods.

It corresponds closely to the figure given by Humbert, excepting that it is only 10 millim. in length instead of 22 millim., and that the antennæ are as hispid as those of *I. solifuga*, Halliday. In Humbert's figure the antennæ are quite glabrous, but as he does not mention this among the differences between his species and *I. solifuga*, it is possibly an error of the draughtsman. The number of joints in the antennæ is almost equal to that of *I. Saussurii*, and more than that of *I. solifuga*; but the animal is but little larger than the type specimens of *I. solifuga* in the British Museum. Another point of difference, though very slight, is in the forceps. In both the above quoted species there is a secondary tooth on the inner edge of each chela, besides several smaller rounded papillæ; now in the specimen from Fernando Noronha this secondary tooth is nearer the apex of the chela than is either of the others.

Distribution. The distribution of the whole genus is very little known at present, as specimens are not often collected. *I. solifuga* occurs in South Europe, Algeria, and Madeira (the var. *Wollastoni*). *I. Saussurii* was obtained in Mexico at Orizaba. Species are also recorded, but not described, from the United States and Calcutta.

Dr. Grassi, in p. 1 of "Progenitori degli Insetti e dei Miriapodi," gives *I. Saussurii* as from Brazil; but does not say whether he has seen Brazilian specimens; and in his list of species mentions it merely from Mexico, evidently using "Brasili" as a synonym for Mexico. It is more than probable that, if sought for, it will be found to occur also on the mainland of Brazil.

LEPISMA LEAI, n. sp.

Though it was to be expected that house-inhabiting Lepismas would occur here, I sought for them in vain until just as we were leaving, when a single large *Lepisma*, perhaps disturbed by the packing-operations, appeared. The specimen was somewhat damaged in capturing it; but as it seems to be undescribed, and is a very curious animal, I describe it as it is.

Corpus 19 millim. longum (setis exclusis), griseum. Caput parvum, subrotundatum. Antennæ filiformes (fractæ). Oculi minimi, nigri, pone basin antennarum positi. Prothorax 3 mm. longus, margine superiore recto, inferiore excavato, marginibus lateralibus productis; mesothorax et metathorax similes sed breviores. Pedes coxis valde crassis, brevibus, oblongo-ovalibus,

subtus duabus setis longis; articulis secundis longioribus multo tenuioribus pubescentibus, supra spina crassa armatis; tertiis tenuioribus, æquilongis, subtus setiferis; tarsis multo brevioribus setiferis, uncis parvis duobus terminalis. Inter coxas tres squamæ, ovales, obtusæ, quam coxas minores. Abdominis segmenta subæqualia, glabra. Segmentum ultimum breve. In medio penultimi segmenti appendices duæ breves, complanatæ, acutæ; post eas duæ laterales, breves, teretes, hispidæ, tunc duæ longæ multo longiores et tenues hispidæ, tunc duæ longæ graciles hispidæ, et in medio appendix longissima unica, crassior, setosa, articulata et annulata.

The abdomen was filled with some bright green substance, which was emitted from the mouth when touched—apparently green paint nibbled off the shutters.

The most nearly allied species to this which I have seen was obtained in Socotra, and is now in the British Museum. The breadth of the thorax is greater than in *L. saccharina*, but the head is not concealed as in some species.

LEPISMA CORTICOLA, n. sp.

Parva, 1 cm. longa, angusta, metallica plumbea, dorso arcuato nec complanato. Caput parvum, rotundatum; oculi ad basin antennarum, rubri. Antennæ graciles, annulatæ, hispidæ; articulus basalis maximus, reliqui breves, plurimi, crassiusculi. Palpi maxillares 5-articulati, articulis breviusculis. Palpi labiales breves, clavati; articulus basalis brevis sectus, secundus longior, tertius brevissimus conicus, quartus rotundatus brevis. Thorax angustus, quam abdomen vix latior. Prothorax quam mesothorax longior, metathorax brevior, marginibus omnium ciliis rigidis munitis. Pedes longiusculi, hispidi; coxæ breves, latæ nec crassæ; secundo paullo angustior et brevior; tarsi longiusculi, triunguiculati; squama inter coxas prothoracis ovata acuta magna, alteræ minores. Abdomen breviusculum; appendices segmenti ultimi graciles, hispidæ, breviusculæ, subæquales.

In rotten wood and under stones in the Sapate and the base of the Peak. It also occurred on the mainland at Pernambuco in similar localities.

The chief peculiarity of this *Lepisma* is its very rounded back, resembling that of a *Machilis* rather than that of a typical *Lepisma*. It is a small active species occurring singly, of a dark leaden-grey colour. The scales resemble those of *L. saccharina* in outline, but are more notched at the upper edge, and seem

also to have more numerous ridges. The thorax is not much broader than the abdomen, and the margin does not extend much beyond the feet.

Machilis, sp.

A single specimen of a very small brown *Machilis* was taken under a stone at the base of the Peak; but, by an accident, the specimen was destroyed, and we met with no others.

Seira musarum, n. sp.

Minuta, gregaria, in vita metallica, 1 mm. longa. Caput rotundatum, hispidum; oculi in maculis nigris fascia obscura sæpe connectente. Antennæ breviusculæ, violaceæ, hispidæ; articulo basali brevissimo, secundo et tertio subæquali basali duplo longioribus; articulo quarto triunciali, longissimo. Collum distinctum. Segmentum secundum corporis (prothorax) latum, marginibus rotundatum; tertium brevius, quartum multo brevius, quintum longius, sextum quinto subæquale, septimum sexto triplo longius, terminalia brevia. Corpus in speciem fermo glabrum, insquamosum, flavescens, segmentorum basibus et marginibus cæruleo-purpureis. Pedes hispidi, primi breviusculi, secundi longiores, tertii longissimi, graciles.

Very abundant between the wet bases of the petioles of the bananas, at the base of the Peak.

It is very nearly allied to *S. Buskii*, Lubb., which was described from specimens found in a hot-house in England, and probably introduced with tropical plants. It differs in the absence of hairs round the neck and on the body, longer hind legs, and also in coloration. The spring resembles that of *S. Buskii*, and is rather hispid. The neck is very distinct. These small Collembola have been much neglected by collectors, and it is most probable that this species was introduced in the bananas.

ECHINODERMATA*.

There were not many species of Echinoderms found on the island, but the following were obtained:—

Cidaris tribuloides, *Lamk.*

Very plentiful on the north side of the island in coral-reef pools, near Sambaquichaba and Morro do Chapeo.

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* The species were determined for me by Prof. Jeffrey Bell.

DIADEMA SAXATILE, *L.*

Two specimens from pools at Morro do Chapeo.

TRIPNEUSTES ESCULENTUS, *Leske.*

Very plentiful in rock-pools in Sponge Bay, sometimes almost filling a small pool.

OPHIURA CINEREA, *M. & Tr.*

Common under stones, north side.

OPHIACANTHA sp.

A very small specimen with the preceding.

OPHIOCOMA PUMILA, *Lütk.*

Young specimens.

OPHIOCOMA ECHINATA, *Ag.*

A single specimen from Portuguese Bay. Quite unknown to our guide, so it is probably rare here.

OLIGOCHÆTA.

By W. BLAXLAND BENHAM, D.Sc.

On February 2, 1889, I received a tube of small worms, which had been collected by Mr. H. N. Ridley in the island of Fernando Noronha, with the request that I would identify them. I gladly undertook to do so, and obtained permission to open the worms, if necessary; for it is now admitted that in most cases it is almost impossible to pronounce with certainty on the genus of an Earthworm from external characters alone; and although in some cases external characters may point to some particular genus, yet it is not always safe to rest content with such an indication, and we must examine the internal anatomy in order to be sure of the point.

The tube which I received contained six small, ill-preserved worms, one of which was a Polychæte, which I did not further examine. Of the remaining five, the first (which I will call A) was of rather an earthy-brown colour and measured 4 inches in length; the second and third were similar in colour and general appearance, but were only about 2 inches long; the fourth (B) was of a much darker tint, and was reddish brown in colour, somewhat like that of *Lumbricus terrestris*; it measured 5½ inches; the fifth turned out to be merely the anterior portion of a similar specimen.

The Worm A.—The first feature which struck me was the quincuncial arrangement of the setæ in the posterior region of the body; anteriorly the setæ are in couples.

The body-wall, being somewhat transparent, allowed me to distinguish through it paired light-coloured bodies, or "pyriform sacs," lying in the ventral region posteriorly. The most anterior somite of the body is very elongate, and carries the mouth terminally, the prostomium being absent. These features recalled the genus *Urochæta* of Perrier; but somewhat similar characters are found in other Earthworms: thus the pyriform sacs have been described by myself in *Urobenus* *; and the scattered condition of the setæ, though not identical with the arrangement noticed, closely resembled, and might easily be confounded with, what obtains in *Diachæta* (Benham).

Turning then to the clitellum, I found it to cover the somites XIV. to XXII. or XXIII.; it is not complete on the ventral surface; and both anteriorly and posteriorly is, as is often the case, more feebly developed. One peculiar feature, however, about the clitellum, which therefore recalled *Urochæta*, is the fact that the intersegmental grooves are deep and noticeable; the glandular structure not being continuous from somite to somite, as is the case in most other Earthworms.

I could see no pores, or external apertures, of the genital ducts or nephridia; I therefore opened the worm, in the ordinary way, by a median dorsal incision, in order to satisfy my suspicion as to its belonging to the genus *Urochæta*.

The septa are thin, with the exception of four situated anteriorly, which are greatly thickened, namely those forming the posterior wall of somites VI., VII., VIII., and X. (the septum between IX. and X. is absent). Such thickened muscular septa are not unusual in Earthworms; but whether their position is constant in a given species is by no means certain. Perrier has not helped us to settle the matter, since in his figure he represents only four such septa, whereas in the text he speaks of five of them. However, Beddard †, in a species of this genus from Australia, describes four, having the same position as in the worm under consideration.

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* Quart. Journ. Micr. Sci. vol. xxvii.

† Proc. Roy. Soc. Edinb. xiv. 1887, p. 160.

The alimentary tract, the vascular system, the nephridia, all exhibit the characters peculiar to or present in *Urochæta*.

There is but a single pair of seminal reservoirs, which have a greater extent than in *U. corethrura* (F. Müller [*]); for in the present specimen that lying on the left side passes through eight somites, that of the right side passes through twelve somites, commencing in somite XII., where are situated also the ciliated rosettes.

I was unable to trace the sperm-ducts; I could find no ovary; I did not look for testes, as this would have necessitated some damage to the worm, which I was anxious to injure as little as possible.

There are three pairs of spermathecæ; each is a very elongate, thin-walled sac, enlarged distally, and lying respectively in somites VII., VIII., IX. The chief difference between the two species of *Urochæta* that have received names lies in the different position of the spermathecæ. In *U. corethrura* they lie in somites VIII., IX., X.; in *U. dubia* (Horst) they are found in somites VI., VII., VIII.; in Beddard's specimen from Australia they have the same position as in the present specimen.

Such is a brief sketch of the anatomy of the worm A, from Fernando Noronha; it is sufficient, however, to identify it as belonging to the genus *Urochæta*; but as to the species—whether it belongs to any of those already described or requires a new name—I feel rather diffident of expressing an opinion. In most points it agrees closely with *U. corethrura*; but in the position of the gizzard (in somite VI. instead of VII.), in the position of the spermathecæ, and in the fact that the setæ are not bifid, the two forms differ. On this last point I think no great stress can be laid, as Beddard recognizes no bifidity in his Australian specimen; and I agree with him so far as the present specimen is concerned, which differs also from Horst's species, *U. dubia*, in the position of the spermathecæ; in fact, with regard to these organs, the present and Beddard's specimen are intermediate between Horst's and Perrier's species. But are we justified in establishing a new species on such slender grounds, and from an examination of a single specimen? I think not, and prefer to leave the specimen unnamed, and to regard it as belonging to Perrier's species, of which it may be a variety; for we are at present ignorant as to how far

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[*] See Perrier, Arch. d. Zool. expér. et gén. iii. 1874.

variation may occur in Earthworms; since with the exception of Beddard's paper on *Perionyx* (Journ. Linn. Soc., Zool. 1886, p. 308), we know absolutely nothing of the subject, and the present specimen forms a step between *U. corethrura* and *U. dubia*.

The two small worms resemble the specimen A in colour and in external characters; the clitellum is, however, undeveloped, so that they are probably young specimens of the same worm.

The worm B is longer than A, and of a somewhat different colour, being of a rather more reddish or violet-brown tint.

The body-wall is transparent, and showed white pyriform sacs through it much more distinctly than is the case with A.

The worm is, however, so soft that no setæ protrude, and I was unable to satisfy myself as to their exact arrangement posteriorly; anteriorly they are paired; posteriorly they are scattered, but whether regularly or not I cannot be positive.

The clitellum occupies somites XIV. to XXIX., and is thus rather more extensive than in A; but the worm is so soft that it is difficult to count with accuracy the somites, as some of the rings may be merely annuli. Thus far, then, we have no indication as to its genus; but on opening it, the arrangement of the septa, seminal reservoirs, and spermathecæ are seen to agree with what is found in A.

This second worm is therefore *Urochæta*, and doubtless the same species as the preceding.

It will be seen that I have made no morphological studies of these worms, nor sought to do more than identify them. Indeed, they were too badly preserved to be of any use histologically, and I should not have felt justified in sectionizing them even if they had been in good condition.

The fact that these worms belong to the genus *Urochæta*, which has been already described from Brazil and some of the neighbouring islands, lends considerable support to Mr. Ridley's supposition that they have been imported from the mainland in the mould in which cultivated plants were brought to the island. In conclusion I must express my best thanks to Mr. Ridley for allowing me to examine and identify them.

PORIFERA.

By H. J. Carter, F.R.S.

Dry Specimens.

These were all too much beach-worn for specific distinction. The Nos. correspond with those on the Specimens.

1. Polytherses, *Duchassaing et Mich.*[*]

2. Hircinia.

3. Chalina.—Spicules fine, slender, acerate.

4. Hircinia.—Fine structure.

5. Euspongia ("best Turkey Sponge" of commerce).

6. Euspongia.—Bearing *Polytrema miniaceum.*

7. Hircinia.—Skeletal structure partially filled with the filaments of *Spongiophaga communis.*

Wet Specimens.

Most of these are too fragmentary for specific distinction, although possessing the natural characters which they presented when taken from their habitat.

8. Polytherses.—Two coarse pieces alone; the rest on pieces of a fine *Hircinia.*

9. Euspongia ("best Turkey Sponge" of commerce").—Three or four discoloured pieces.

10. Chondrilla nucula, *Sdt.*

11. Geodia.—? *G. Tumulosa, Bk.*—Siliceous balls spherical. Zone-spicule trifid; arms simple, undivided, extending upwards, outwards, and lastly horizontally. Bearing *Polytrema.*

12. Chondropsis arenifera, *Cart.* (Ann. & Mag. Nat. Hist. 1886, vol. xvii. p. 122).—Acuate spicules, sometimes blunt at each end.

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[*] It should be remembered that "*Polytherses*" is a *Hercinia* in which the soft parts have been replaced by a structure composed of the filaments of *Spongiophaga communis,* Cart., which is of world-wide occurrence, but of which the nature is still unknown.

13. CHALINA ? species.—Dark, dirty; fragments still bearing traces of their natural red-purple colour. Extending horizontally; throwing up thick ridges; scattered over with short, erect, tubular vents of different lengths. Fibre tough, charged abundantly with comparatively large, acerate spicules. Several pieces, some accompanied by a portion of *Chondropsis arenifera.*

14. EUSPONGIA ("fine Turkey sponge" of commerce).—Typically good, but small specimen; presenting the characteristic, crinkled surface. Colour black above, light sponge-yellow below. Bearing *Polytrema.*

15. CHONDRILLA NUCULA, *Sdt.*—Typically good specimen, growing over sand-detritus mixed with *Polytrema.*

16. CHONDRILLA PHYLLODES, *Sdt.*—Antilles. Spicules of two kinds, viz., pin-like skeletal, and spinispirular flesh-spicule. Closely allied in this respect to *Spirastrella cunctatrix*, Sdt. Colour grey or violet. Consistence gelatinous, firm. Three typically good specimens growing over sand-detritus mixed with *Polytrema* covered with white *Melobesia.*

17. CHONDROPSIS ARENIFERA.—Black on the surface from a layer of brown pigmental cells. Growing over a black *Stelletta* (? species), also bearing a cortical layer of dark brown-black pigmental cells mixed with small stellates. Zone-spicule trifid. Arms simple, straight, extended upwards and outwards.—Four large pieces.

18. CHONDRILLA NUCULA, *Sdt.*—Small, but typically good specimen.

19. SYNASCIDIA.—Common form. Globular, radiated calcareous spicule. Colour purple-white. Two pieces.

20. CHALINA ? species.—Same as No. 13. One piece bearing a bit of *Hircinia.*

21. EUSPONGIA ("best Turkey sponge" of commerce).—Three small pieces.

22. ? ALCYONIUM OR HYDROID ZOOPHYTE.—Digitate, reptant; colour yellowish; consistence soft.

23. ACTINIA ? sp.—Now lead-colour.

24. Alcyonium.—Congregated, short, columnar individuals; constricted circularly throughout the column.

25. EusponGIA ("Honeycomb sponge" of commerce).—Coarse cavernous structure.

26. Euspongia.—Ditto.

27. Geodia, same as No. 11.—Fragments of skin and body-substance only.

28. Donatia lyncurium.—Four specimens; the largest ¾ in. in diameter.

29. Polytherses, with skeletal structure of *Hircinia* protruding.

30. Euspongia ("Honeycomb sponge" of commerce).—Coarse cavernous structure.

31. Suberites massa, *Sdt.*—Spicule of one form only, simply pin-like, with subglobular head. Eight fragments. Surface warty. Colour yellowish.

32. Axinella ? species.—Form of specimen globular, about an inch in diameter, composed of radiating, erect, tough fibre, charged throughout with projecting tufts of simply acuate curved spicules; of one form only.

33. Tethya cranium.—Two small, discoloured, black fragments.

34. Chondropsis arenifera.—Specimen triangular, elongate; 4 inches long. Bearing *Polytrema* and *Melobesia*.

35. Euspongia ("Honeycomb sponge" of commerce).—Coarse, cavernous structure. Three pieces. Colour black above, light sponge-yellow below.

36. Chondropsis arenifera.—Good, but small typical specimen.

37. ? Hymeniacidon sanguinea, *Bk.*—Small insignificant specimen. Spicule of one from only, viz. pin-like and slightly curved. Colour now yellowish.

38. Leuconia sacculata, n. sp. (Calcisponge).—Form of specimen sacculated, consisting of four or more inflations

projecting from a common cavity. Colour white. Entire specimen about an inch long, and $\frac{3}{4}$ of an inch in diameter ($1 \times \frac{3}{4} \times \frac{3}{4}$ inch); broken out on one side, if not the point of attachment. The uppermost or principal division ending in a peristomatous mouth, which can only be seen with a microscope, hence to the unassisted eye looks "naked"; $\frac{2}{12}$ in. in diameter. The same on the summit of each inflation, but reduced to the size of a pin's head. Surface of the body smooth, composed of intercrossing arms of quadriradiate spicules *only*, between which are the pores. Vents as just described, leading into a general cloacal cavity corresponding in its inflations with those of the body. Surface of the cloaca scattered over with holes of very different sizes, very irregularly situated in a layer of minute quadriradiates whose fourth arm is much smaller than the rest, curved towards the oral orifice and projecting plentifully above the surface of the cloaca. The spicules of three kinds, viz. 3-radiate, 4-radiate, and linear cylindrical accrate.

Wall of the body about $\frac{1}{16}$ in. in diameter, composed of three layers of spicules, viz.:—1, consisting of comparatively large quadriradiates whose shaft projects inwards and whose other three arms are spread out horizontally over the surface; arm about $\frac{1}{45}$ by $\frac{1}{300}$ in. in its greatest diameters; 2 (the middle substance of the wall), consisting of 3- and 4-radiates mixed irregularly, whose arms are about the same size as that of the quadriradiates of the first or external layer; 3, or internal layer, forming the surface of the cloaca, and consisting of *minute* or infinitely smaller quadriradiates, whose shafts are directed outwards; the other two arms horizontal, and the fourth, or "spine" as it has been called, which is much the smallest, projecting above the surface in the way mentioned. Peristome consisting of palisading spicules about $\frac{1}{300}$ in. long, very fine and straight with abruptly pointed ends, crossed and kept in position by the spreading arms of the quadriradiates of the third, or cloacal, layer, here much enlarged. Wall permeated by branched canals, which commencing on the pores on the surface end in the holes or apertures on that of the cloaca.

Loc. Island of Fernando Noronha.

39. Geodia.—Fragments of skin and body-substance. Same as No. 11, &c.

Summary of Specimens, arranged according to the Author's Classification (Ann. Mag. N. H. 1875, vol. xvi. p. 43).

Order I. CARNOSA.

Family GUMMINIA.

CHONDRILLA NUCULA, *Sdt.* 10, 15, 18.
CHONDRILLA PHYLLODES, *Sdt.* 16.

Order II. CERATINA.

None.

Order III. PSAMMONEMATA.

EUSPONGIA ("fine Turkey sponge" of commerce). 5, 6, 9, 14, 21.

EUSPONGIA ("Honeycomb sponge" of commerce). 25, 26, 30, 35.

HIRCINIA. 2, 4, 7.
POLYTHERSES. 1, 8, 29.

Order IV. RHAPHIDONEMATA.

CHALINA. 3, 13, 20.

Order V. ECHINONEMATA.

AXINELLA. 32.

Order VI. HOLORHAPHIDOTA.

HYMENIACIDON SANGUINEA, *Bk.* 37.
SUBERITES MASSA, *Sdt.* 31.
DONATIA LYNCURIUM. 28.
CHONDROPSIS ARENIFERA, *Cart.* 12, 17, 34, 36.
GEODIA, 11, 27, 39.
TETHYA CRANIUM. 33.

Order VII. HEXACTINELLIDA.

None.

Order VIII. CALCAREA.

LEUCONIA SACCULATA, n. sp. 38.

Remarks.

Of the present collection, it may be stated that the facies is West-Indian. *Chondrilla phyllodes*, Sdt., has as yet only been chronicled by that author, and that, too, from the "Antilles" (Grundzüge Spong.-F. atlantisch. Gebietes, p. 26). "*Polytherses*" was the name given by Duchassaing and Michelotti to this transformed, sponge-like body which they dredged in the Caribbean Sea, and whose constituent parts have been above noticed. Both sorts of the Officinal Sponge, viz. the "Best Turkey" and the "Honeycomb" of Commerce, are plentiful, as they are in the West Indies generally. The Calcisponge, *Leuconia sacculata*, is a new species.

MADREPORARIA.

By Prof. P. Martin Duncan, M.B. (Lond.), F.R.S., &c.

Section MADREPORARIA APOROSA.

Family Astræidæ, *Ed. & H.*

Subfamily Astræidæ reptantes.

Astrangia solitaria, *Lesueur*, sp., *Verrill, Bull. Mus. Comp. Zoöl.* No. 3; *Pourtalès*, 1871, *Ill. Cat. Mus. Comp. Zoöl.* p. 79.

A specimen much covered with Nullipores. The corallites smaller than the Florida types, and the so-called "pali" not united before the second and third cycles of septa. The form is allied to *Astrangia Danæ* and to *A. Michelini.* It may be considered as a small variety of the Floridan species.

Subfamily Astræidæ cæspitosæ.

Mussa, sp.—A worn specimen of a species.

Subfamily Astræidæ agglomeratæ fissiparantes.

Favia conferta, *Verrill*, 1867, *Trans. Connect. Acad.* vol. i., *in Hartt's Collection of Corals from the Abrolhos Reef, Brazil*, p. 355 (1868).

This species is remarkable for its elongated calices due to fissiparity, and for their closeness. Often a ridge separates the neighbouring calices, instead of some vestige of interspace and costæ.

Verrill and Pourtalès noticed the alliance of the species with the genera *Goniastræa* and *Mæandrina*. In a small specimen the Goniastroid appearance is striking, and the costæ between the calices are only visible at one spot. There are several rolled specimens, and, as Pourtalès remarked, they resemble Goniastroids very much.

FAVIA ANANAS, *Lamarck*, sp.

The specimens have the usual well-developed columella, the costæ are very visible in one, and the fourth cycle of septa is incomplete.

FAVIA DEFORMATA, *Ed. & H.*, *Hist. Nat. des Corall.* vol. ii. p. 434.

A somewhat worn and broken coral, very Cœlorian in appearance, and with large calices, some long and serial in appearance, but really the result of fissiparity, appears to be a specimen of this form, the habitat of which has hitherto been unknown. The walls are close, but in many places their former separation can be shown. It is a very erratic species, and better specimens are required.

A very worn specimen of the same species was also obtained.

These two specimens came from Rat Island. They were washed up on the south-east corner with a number of Sponges.

Section MADREPORARIA FUNGIDA.

Family PLESIOFUNGIDÆ, *Duncan*.

Revision of the Genera of Madreporaria, Journ. Linn. Soc. vol. xviii. 1884, p. 133.

SIDERASTRÆA SIDEREA, *Ellis & Soland.*, sp.

This specimen, and indeed all the rolled ones besides, have smaller calices than the Caribbean type, but that is the only distinction. They greatly resemble *Siderastræa stellata*, Verrill, from the Abrolhos Reef.

Remarks.

This little Coral fauna has the Abrolhos Reef homotaxis, and the species are fairly intermediate between those of the same genera of that reef and of the Caribbean Sea.

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Receipts and Payments of the Linnean Society, from May 1st, 1889, to April 30th, 1890.

Receipts.				£	s.	d.
Balance at Bankers' on 1st May, 1890				315	17	7
Interest on Investments				196	4	11
Admission Fees				222	0	0
Annual Contributions				1587	9	3
Compositions				225	0	0
Sales of Publications:—						
Transactions	£91	0	10			
Journals	123	6	9			
Proceedings and Catalogues	0	0	0			
				214	7	7
Donations				275	0	0
				£3035	19	4

Payments.				£	s.	d.
Taxes and Insurance				19	13	9
Repairs and Furniture				72	8	7
Coals and Gas				54	10	8
Salaries				538	10	0
Library:—						
Books	£164	14	7			
Binding	124	7	1			
				289	1	8
Expenses of Publications:—						
Printing	£654	10	10			
Illustrations	317	12	8			
Distribution	79	3	1			
				1051	6	7
Miscellaneous Printing and Stationery				56	8	10
Petty Expenses (including Tea and Postage)				68	14	6
Investments				550	0	0
Balance at Bankers' on 30th April, 1890				335	4	9
				£3035	19	4

Investments on April 30th, 1890.

	£	s.	d.			£	s.	d.
Consols	4475	8	3	@	98 p. c.	4385	18	1
Metropolitan Board of Works 3½ per cent. Stock	1079	11	3	@	112½ „	1205	1	3
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May 14th, 1890.

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Journal of Zoology.

Vol. XX. is completed with the issue of the present number, and contains Nos. 116 to 125 inclusive, with Title and Index to the Volume.

Vol. XXI.—Devoted to the Fauna of the Mergui Archipelago, comprises Nos. 126 to 135 inclusive, all of which have been published, with Title and Index to the Volume.

Vol. XXII., devoted to Dr. De Man's Report on the Crustacea of the Mergui Archipelago, comprises Nos. 136 to 140 inclusive, all of which have been published, with Title and Index to the Volume.

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The Meetings of the next Session, commencing in November, will be duly announced.

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